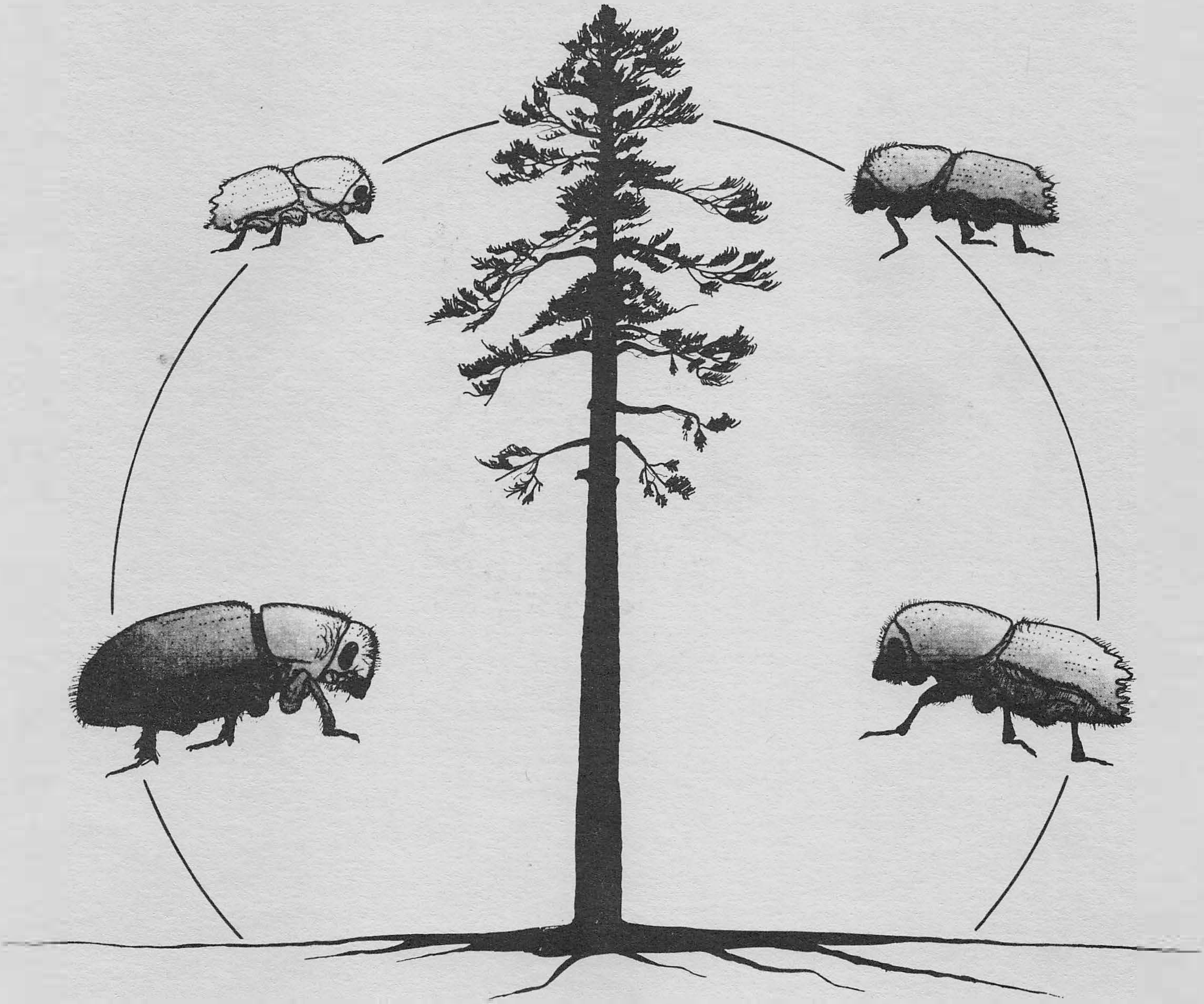
M. Haverain

January 1984 Monograph No. 12

# Annotated Bibliography of *Dendroctonus terebrans* (Olivier), *Ips avulsus* (Eichhoff), *Ips grandicollis* (Eichhoff), and *Ips calligraphus* (Germar) in the Southeastern U.S.A.

John L. Foltz, Edward P. Merkel, and Robert C. Wilkinson



Agricultural Experiment Stations
Institute of Food and Agricultural Sciences
University of Florida, Gainesville
F. A. Wood, Dean for Research

# Annotated Bibliography of *Dendroctonus terebrans* (Olivier), *Ips avulsus* (Eichhoff), *Ips grandicollis* (Eichhoff), and *Ips calligraphus* (Germar) in the Southeastern U.S.A.

John L. Foltz
Edward P. Merkel
Robert C. Wilkinson

## CONTENTS



## ACKNOWLEDGMENTS

This research was funded in part by grants from the Georgia Forestry Commission and a U.S. Department of Agriculture-sponsored program entitled "The Integrated Pest Management RD&A Program for Bark Beetles of Southern Pines," Cooperative Research Agreement 19-80-406. Any opinions, findings, and conclusions or recommendations in this publication are those of the authors and do not necessarily reflect the view of the funding agencies. We are indebted to numerous colleagues who reviewed drafts of this monograph and also pointed out and frequently provided missing publications. We thank Wayne Dixon for the cover illustration.

## ABSTRACT

Annotates 466 papers on *Dendroctonus terebrans* (Olivier), *Ips avulsus* (Germar), *I. grandicollis* (Eichhoff), and *I. calligraphus* (Eichhoff) (Coleoptera: Scolytidae). Papers are indexed by author, subject, and bark beetle species.

## INTRODUCTION

This annotated bibliography is published as an aid to researchers interested in the abundant and often hard-to-acquire literature on *Dendroctonus terebrans* (Olivier), *Ips avulsus* (Eichhoff), *I. grandicollis* (Eichhoff), and *I. calligraphus* (Germar). We begin with brief taxonomic histories of the four species so readers can follow and understand the succession of names used through the years. Next is the bibliography, arranged alphabetically by first authors and then chronologically for each author. Following the bibliography are indexes to the descriptive terms, authors, and bark beetle species of each citation.

All citations included in this bibliography are part of a FAMULUS reprint classification file[1] we maintain at the University of Florida. We would welcome corrections, additions, and suggestions from the reader. In addition, we may be able to help investigators by conducting keyword searches of the pre-1970 literature, the approximate starting date for computerized data bases such as BIOSIS and C.A.B. Abstracts.

## TAXONOMIC HISTORIES

A. G. Olivier described the black turpentine beetle in 1795 and gave it the name *Scolytus terebrans*. In 1836 Erichson placed the species in the genus *Dendroctonus*. Although LeConte described the red turpentine beetle as *D. valens* in 1860, he erroneously synonymized it with *D. terebrans* in 1868. It was not until Hopkins' work in the early 1900's that the confusion between the two species was rectified. Therefore, in our annotated bibliography of the *D. terebrans* literature, we have documented misuses of the name as well as including the literature properly pertaining to the species.

*Ips calligraphus* was the first of the three engravers to be described when in 1824 E. F. Germar ascribed the name *Tomicus calligraphus*. Synonyms include *Bostrichus exesus* Say (1826), *B. chloroticus* Dejean (1837), *B. conformis* Dejean (1837), *Tomicus praemorsus* Eichhoff (1868), and perhaps *T. interstitialis* Eichhoff (1869) and *I. ponderosae* Swaine (1925). Lanier(1972), based on karyological and morphological data, removed *interstitialis* from synonymy and described *ponderosae* as a subspecies of *calligraphus*; S. L. Wood (1982) states that until considerably more information is available only one species should be recognized. In the present bibliography we have generally limited our annotations to papers on *Ips calligraphus calligraphus* as defined by Lanier and have not attempted to acquire and annotate literature on *I. interstitialis* in Central America and *I. ponderosae* in the West.

*Ips grandicollis* and *I. avulsus* were described in the genus *Tomicus* by Eichhoff in 1868. The latter species has no synonyms. Synonyms of *I. grandicollis* include *Bostrichus pini* Zimmermann (1868), *T. cacographus* LeConte (1868), and *I. chagnoni* Swaine (1916). There is disagreement between S. L. Wood (1957, 1982) and Lanier (1970) as to whether *Tomicus cribricollis* Eichhoff (1869) and its synonym *Ips cloudcrofti* Swaine (1924) are also synonyms of *I. grandicollis*.

[1]Ashley, Tom R. 1981. FAMULUS: A reprint classification system for the research scientist. Bull. Entomol. Soc. Am. 27(3):161-165.

# BIBLIOGRAPHY


1 Adams, J.E.
1937. **Control of southern pine beetle [*Dendroctonus terebrans*].** Arborist's News 2(5):3-4.

The author is clearly describing the work of the black turpentine beetle despite "southern pine beetle" in the title. He observes that newly attacked trees usually occur to the southeast of the original infested trees and that lead arsenate sprays to a height of 8-10 feet on the bole effectively prevent beetle attacks.
ATTACK, DAMAGE, CHEMICAL CONTROL

2 All, J.N.
1970. **The influence of various odors on host selection by pioneer beetles of *Ips grandicollis*.** Durham, NC: Duke Univ. School of Forestry. vi + 74 p. 17 tabs, 9 figs, 88 refs. M. Sci. Thesis.

See All and Anderson 1972, 1974.
SEX RATIO, SEMIOCHEMICALS, MATING, OVIPOSITION, ATTACK, HOST FINDING, GALLERY PATTERN

3 All, J.N.; Anderson, R.F.
1972. **Initial attack and brood production by females of *Ips grandicollis* (Coleoptera: Scolytidae).** Ann. Entomol. Soc. Am. 65:1293-1296.

*Ips grandicollis* frequently initiated egg galleries without an associated male in logs placed adjacent to male-infested bolts. Previously mated females produced egg galleries 10-20 cm long and packed with borings for one-fourth to one-half their length; larval galleries radiated out in the typical manner. Unmated females produced shorter, more winding galleries which contained no eggs.
BIOLOGY, LIFE HISTORY, BEHAVIOR, MATING, OVIPOSITION, ATTACK, GALLERY PATTERN

4 All, J.N.; Anderson, R.F.
1974. **The influence of various odors on host selection by pioneer beetles of *Ips grandicollis*.** J. Ga. Entomol. Soc. 9:223-228.

Logs treated with turpentine, piperonal, citral, and carbon disulfide had significantly more attacks than did untreated logs. Logs treated with ammonium hydroxide had fewer attacks. Examination of logs infested by just one beetle showed that females were the pioneers 4 times as frequently as the males.
SEX RATIO, SEMIOCHEMICALS, HOST FINDING, PIPERONAL, TURPENTINE, ALPHA-TERPINEOL, CITRAL, ACETIC ACID, AMMONIUM HYDROXIDE, CARBON DISULFIDE, PYRIDINE, 0-METHOXYPHENOL]

5 Allen, J.D.
1973. **Pests and diseases of radiata pine — Some observations made during a visit to Australia, South Africa, Kenya, Spain and Chile.** N.Z. J. For. 18:265-272.

Presents some observations and speculations on the more important diseases, insect pests, and climatic and edaphic stresses encountered in the author's 1972 visits to the radiata pine producing countries. The author concludes that the killing of large groups of trees by *Ips grandicollis* in Australia is asssociated with severe drought stress. In nondrought situations the beetles attack trees only when logs and slash are not continuously available and when residues are too close to standing trees.
FUNGI, CULTURAL CONTROL, SALVAGE, HOST TREES, DROUGHT

6 Anderson, N.H.
1967. **Some relationships between host tree condition and suitability for attack and brood rearing by *Ips* bark beetles.** Durham, NC: Duke Univ. School of Forestry. 169 p. Dissertation. Available from Univ. Microfilms International, Order No. 67-17203.

Experiments with *Ips calligraphus* and *I. grandicollis* caged on standing and felled loblolly pines in North Carolina showed no correlation between current radial growth rate and *Ips* attack densities. Attack densities and brood development were also unrelated to phloem moisture content and phloem pH over the observed ranges of these variables. Attacks were unsuccessful until the oleoresin exudation rate (O.E.R.) became negligible (less than 0.1 ml/hr from a 0.5-inch hole); developing broods failed whenever the O.E.R. increased above this same value. [See N. H. Anderson & D. B. Anderson (1968) for the results of research on a lightning-struck pine.]
REARING, REPRODUCTION, EGGS, LARVAE, ADULTS, FECUNDITY, DISTRIBUTION, OVIPOSITION, ATTACK, FLIGHT, BROOD MATERIAL, PHYSICAL CONTROL, TREE PHYSIOLOGY, STRESS, OLEORESIN EXUDATION PRESSURE, OLEORESIN EXUDATION RATE, PHLOEM MOISTURE, PHLOEM PH, RADIAL GROWTH, LIGHTNING

7 Anderson, N.H.; Anderson, D.B.
1968. ***Ips* bark beetle attacks and brood development on a lightning-struck pine in relation to its physiological decline.** Fla. Entomol. 51:23-30.

*Ips calligraphus* and *I. grandicollis* started infesting a loblolly pine in the midbole region a few days after it was struck by lightning. *Ips avulsus* and *I. grandicollis* initiated the mass attack in the upper bole about 4 weeks after the strike; *I. calligraphus* mass attack of the lower bole occurred about one week later. Successful attacks began near the lightning fissure when the oleoresin exudation rate from a No. 5 cork borer hole declined to less than 0.1 ml/hr. The phloem moisture content had little effect on attacks and brood development except in cases of extreme water loss.
BEHAVIOR, ATTACK, TREE PHYSIOLOGY, OLEORESIN PRODUCTION, PHLOEM MOISTURE, PHLOEM PH, LIGHTNING

8 Anderson, R.F.
1977. **Dispersal and attack behavior of the southern pine engraver, *Ips grandicollis* Eichh., Coleoptera, Scolytidae.** Pages 17-23 in Kulman, H.M., and H.C. Chiang, eds., Insect Ecology — Papers Presented in the A. C. Hodson Lectures. Minn. Agric. Exp. Stn. Tech. Bull. 310. 107 p.

Summarizes previous work by the author and his students to determine (1) how pioneer beetles first reach suitable hosts, (2) the efficiency of the pheromone produced by attacking beetles in attracting other beetles, and (3) what effect various meteorlogical factors have on the activity of dispersing beetles. The results indicate that attractants produced by susceptible host material emanate from the intact host logs, not from exposed wounds, and that pioneer beetles are able to detect suitable host material from some distance before alighting. The combination of pheromone and host odors is much stronger than the odors emanating from suitable host material by itself. It appears that emerging *Ips grandicollis* have the inherent behavior to first disperse and/or their sensory receptors are not sufficiently sensitive to detect the attracting odors. This general type of behavior would be

advantageous for the beetle population as a whole because it would help prevent the excessive concentration of insects in localized areas where the odors were strongest.
PHYSICAL FACTORS, LIGHT, TEMPERATURE, WIND SPEED, RELATIVE HUMIDITY, SATURATION DEFICIT, EVAPORATION RATE, ECOLOGY, DISPERSAL, PHEROMONES, PHEROMONE-CHEMICAL COMBINATIONS, SEMIOCHEMICALS, PINENE, ACETONE, TURPENTINE, ANISOLE, PIPERONAL, ETHANOL, AMYL ACETATE, CITRAL, CARBON DISULFIDE, AMMONIA, EUGENOL, 0-METHOXYPHENOL, GERANIOL, TERPINEOL, PYRIDINE, METHYL SALICILATE, ACETIC ACID, BEHAVIOR, HOST FINDING

9 Anonymous.
1965. **Field test wins praise for pesticide carrier.** Naval Stores Review 75(10):9,18.
Describes procedures for mixing the penetrating wetting agent "OO-Seven" (formerly known as "Seven-Eleven") with a 1% BHC water emulsion and discusses the use of this mixture for preventive and remedial control of the black turpentine beetle.
CHEMICAL CONTROL, BHC, WETTING AGENTS

10 Bailey, H.B., Jr.
1976. **Observations on lightwood induction field experiments installed by Union Camp Corporation.** Pages 42-46 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res Coord. Council; 1976 January 20-21; Jacksonville, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 154 p.
Despite the application of a high (8%) concentration of paraquat to a 35-year-old natural stand of slash pine near Rincon, Georgia in March 1974, tree mortality after 1 year, due largely to *Ips* spp., was only 12% of 500 treated trees. The black turpentine beetle attacked trees within 3 weeks after treatment but *Ips* spp. did not attack until 3 months after treatment. The author attributed the bark beetle activity to dry weather, lightning strikes, generally high bark beetle populations in 1974, and the high paraquat concentration used. Spraying all paraquat-treated trees with approximately 1% BHC in diesel fuel to a height of 3 m when study was installed, salvage of infested trees, and additional spraying in July 1974 and April 1975 apparantly prevented worse bark-beetle-caused tree mortality.
PHYSICAL FACTORS, DROUGHT, LIGHTNING, CHEMICAL CONTROL, STRESS, PARAQUAT, LIGHTWOOD INDUCTION, BHC

11 Baker, W.L.
1972. **Eastern forest insects.** U. S. For. Serv. Misc. Publ. 1175. 642 p.
General biology, behavior, and control of the black turpentine beetle and the *Ips* engravers are discussed on pages 244-246 and 260-262, respectively.
BIOLOGY

12 Barker, J.A.
1976. **Observations on lightwood induction field experiments installed by International Paper Company.** Page 47 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1976 January 20-21; Jacksonville, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 154 p.
See Barker & Schmid 1976.
PARAQUAT, LIGHTWOOD INDUCTION

13 Barker, J.A.; Schmid, J.J.
1976. **Paraquat-induced lightering in slash pine.** Pages 88-92 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1976 January 20-21; Jacksonville, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 154 p.
In lightwood induction experiments near Bainbridge, Georgia, bark beetles infested 52% of 400 trees treated with either a 4% or 8% paraquat solution and sprayed with BHC to a height of 6 feet. One year after treatment 9% of the trees had died, primarily due to the earlier beetle attacks.
TREE MORTALITY, LIGHTWOOD INDUCTION, PARAQUAT

14 Barker, W.J.; Nettles, W.C.
1954. **Controlling bark beetles in South Carolina woodlands.** Clemson Agric. Col. Ext. Circ. 239 (rev.). 6 p.
A brief extension publication describing the signs of bark beetle attacks on pines and suggesting methods for preventing and controlling infestations.
ATTACK, CHEMICAL CONTROL, DAMAGE SYMPTOMS

15 Barr, B.A.
1969. **Sound production in Scolytidae (Coleoptera) with emphasis on the genus *Ips*.** Can. Entomol. 101:636-672.
Reviews the world literature on sound production in the Scolytidae, reports the occurrence, location, and structure of sound-producing organs in North American *Ips* species, and presents the results of studies on the role of sound production in *Ips paraconfusus*. Females of *I. avulsus*, *I. grandicollis*, and *I. calligraphus* have the vertex-pronotal type of stridulatory organ. No stridulatory organ was found on the male of any *Ips* species.
MORPHOLOGY, BEHAVIOR, STRIDULATION

16 Barras, S.J.; Perry, T.J.
1971. ***Leptographium terebrantis* sp. nov. associated with *Dendroctonus terebrans* in loblolly pine.** Mycopathol. Mycol. Appl. 43:1-10.
A new species of fungus, *Leptographium terebrantis* Barras & Perry, is described. The fungus was isolated from a pupal chamber, eggs, wing covers, whole bodies, and galleries of the black turpentine beetle in loblolly pine near Elizabeth, Louisiana. The authors described the development of the fungus on various culture media. No perfect fungal stage was observed in nature or in culture. The authors do not discuss the effects of fungus on the black turpentine beetle.
TAXONOMY, FUNGI, PATHOLOGY, CULTURING

17 Barras, S.J.; Perry, T.J.
1975. **Interrelationships among microorganisms, bark or ambrosia beetles, and woody host tissue: An annotated bibliography, 1965-1974.** U. S. For. Serv. Gen. Tech. Rep. SO-10. 34 p.
Contains 244 annotated references with author and comprehensive subject indexes.
BIBLIOGRAPHY, FUNGI, YEASTS, MICROORGANISMS, BACTERIA, SYMBIOSIS

18 Barry, P.J.; McDowell, W.E.
1968. **Bark beetle detection survey, Appalachicola National Forest, Florida.** U.S. For. Serv., SE Area, S. & P. F. Rep. No. 69-1-21. 6 p.
A bark beetle survey was made October 14 and 15, 1968 on the 632,588 acres of land within the boundaries of the Appalachicola National Forest. Corrected survey data revealed 1,686 spots containing 2,144 trees were present on the area surveyed. Most of the bark beetle activity was centered around lightning struck trees and areas where stress has been put on trees due to the deficit in available water over the past 2 or 3 years. All bark beetle activity was the result of *Ips* spp. and the black turpentine beetle.
DAMAGE, SURVEYS

19 Beal, J.A.; Massey, C.L.
1945. **Bark beetles and ambrosia beetles (Coleoptera: Scoly-**

**toidea): With special reference to species occurring in North Carolina.** Duke Univ. Sch. For. Bull. 10. 178 pages, 28 plates.
The first one-third of this bulletin is a general review of the life history, economic importance, ecology, and control of Platypodid and Scolytid beetles. The remainder of the bulletin consists of keys to the egg galleries and adults of the species occurring in North Carolina followed by brief descriptions of the adults, life history, host plants, geographic distribution, and insect associates of each species. The black turpentine beetle is discussed on pages 80-81 and the *Ips* beetles are covered on pages 140-145.
TAXONOMY, MORPHOLOGY, FUNGI, IDENTIFICATION, BIOLOGY, ASSOCIATES, ECOLOGY, CULTURAL CONTROL, APPLIED CONTROL, HOST TREES, DISTRIBUTION, BEHAVIOR

20 Beal, J.A.; Haliburton, W.; Knight, F.B.
1952. **Forest insects of the Southeast: With special reference to species occurring in the Piedmont Plateau of North Carolina.** Duke Univ. Sch. For. Bull. 14. 168 p.
Briefly describes (pp. 50-51) the principal morphological differences between adult *Dendroctonus terebrans* and *D. valens* and mentions that both species may be common where their ranges overlap. Only cursory information is given on the damage and habits of both turpentine beetles. Pages 53-55 contain a brief description of the biology of the 3 *Ips* species and the reader is referred to Haliburton (1943) and Beal and Massey (1945) for additional information.
BIOLOGY, ATTACK, DAMAGE, GEOGRAPHIC DISTRIBUTION

21 Becker, W.B.
1962. **Autumn versus spring spraying of unseasoned pine logs with BHC.** J. Econ. Entomol. 55:1020-1021.
A late autumn spraying was nearly as effective as a spring spraying in preventing the infestation of unseasoned white pine logs in Massachusetts. *Ips calligraphus* was one of six Scolytid species infesting 80-90% of the bark area of untreated logs.
CHEMICAL CONTROL, BHC

22 Becker, W.B.
1964. **Tests with endosulfan to prevent borer damage to unseasoned pine logs.** J. Econ. Entomol. 57:166-167.
Endosulfan (thiodan) effectively prevented *Ips calligraphus* and other beetles from infesting unseasoned white pine logs during the summers of 1961 and 1962 in Massachusetts.
CHEMICAL CONTROL, THIODAN, ENDOSULFAN

23 Bennett, W.H.
1955. **Pine bark beetles.** Tex. For. Serv. Circ. 43. 12 p.
A nontechnical narrative covering the general biologies, symptoms of attack, and direct and preventative control measures for the five bark beetles infesting southern pines.
BIOLOGY, DAMAGE, APPLIED CONTROL

24 Bennett, W.H.
1956 (Revised 1957). **Important insect enemies of southern pines.** U. S. For. Serv. South. For. Exp. Stn., Southern For. Pest Reporter No. 10. 21 p.
An excellent compilation, for foresters and pest detection cooperators, of information on the identification, habits, and control of the bark beetles and other pests of southern pines. [This compilation is the predecessor of the Bennett et al. (1958) and Bennett & Ostmark (1972) papers.]
LIFE HISTORY, BEHAVIOR, ATTACK, CHEMICAL CONTROL, CULTURAL CONTROL,

25 Bennett, W.H.
1958. **What you should know about the black turpentine beetle.** Forest Farmer 18(3):8,16-18.
Contains a series of practical questions and answers concerning the black turpentine beetle and its control.
DAMAGE, CHEMICAL CONTROL, APPLIED CONTROL

26 Bennett, W.H.; Chellman, C.W.; Holt, W.R.
1958. **Insect enemies of southern pines.** U. S. For. Serv. South. For. Exp. Stn. Occas. Pap. 164. 35 p.
Includes a concise and thorough account of the importance, habits, and signs of attack of the bark beetles infesting southern pines. The discussion of control practices is particularly good in recommending various alternative control actions for different forest management situations. [Superseded by Bennett & Ostmark, 1972.]
BIOLOGY, DAMAGE, APPLIED CONTROL

27 Bennett, W.H.
1960. **What's the pitch with the black turpentine beetle?.** South. Lumberman 200(2490):35-36.
This popular-style article is written as an imaginary conversation between a female southern pine beetle and a female black turpentine beetle. In the dialogue the black turpentine beetle tells how she attacks a pine and raises her offspring. The article is both entertaining and informative.
LIFE HISTORY, BEHAVIOR, DAMAGE

28 Bennett, W.H.
1965. **Benzene hexachloride emulsion for controlling black turpentine beetle in logging areas.** J. Econ. Entomol. 58(2):358.
One percent water emulsions of BHC alone and in combination with either an extender or wetting agent gave 88, 90, and 98% protection from black turpentine beetle attack.
CHEMICAL CONTROL, BHC, AROCLOR 5460, WETTING AGENTS

29 Bennett, W.H.
1965. **Silvicultural control of southern forest insects.** Pages 51-63 in C. B. Marlin, ed., Insects in Southern Forests. Proc. 14th Annu. For. Symp., Louisiana State Univ.
A nontechnical paper which includes the author's observations on the role of poor site quality and certain harvesting practices in outbreaks of the black turpentine and Ips beetles.
CULTURAL CONTROL

30 Bennett, W.H.; Ostmark, H.E.
1972. **Insect pests of southern pines.** U. S. For. Serv. South. For. Exp. Stn., New Orleans, LA. 38 p.
Contains concise, illustrated descriptions of the black turpentine and *Ips* beetles, their life histories, signs of attack, stand conditions contributing to population buildups, and recommendations for preventing outbreaks.
BIOLOGY, DAMAGE, APPLIED CONTROL

31 Berisford, C.W.
1968. **Hymenopterous parasites of *Ips* spp. bark beetles (Coleoptera: Scolytidae) in Virginia.** Blacksburg, VA: Virginia Polytechnic Institute. xi + 117 p. 5 tabs, 18 figs, 35 refs. Dissertation. Available from University Microfilms, Ann Arbor, Michigan. Order no. 69-3019.
See Berisford et al. 1970, 1971.
BIOLOGY, PARASITES, HOST TREES

32 Berisford, C.W.; Franklin, R.T.
1969. **Attack sequence of *Ips grandicollis* (Coleoptera: Scolytidae) and some associated hymenopterous parasites.** J. Ga. Entomol. Soc. 4:93-96. 1 tab, 2 figs, 4 refs.
Sticky traps placed on felled shortleaf pines during the summer of 1968 showed that *Ips grandicollis* arrived at a slow rate until ca. day 6 after felling and then at a fast, steady rate until day 27. Females were 1.77 times as numerous as the males, the ratio being nearly constant throughout the arrival period. *Roptrocerus eccoptogastri* (Ratz.), *Heydenia unica* Cook & Davis, and *Coeloides pissodis* (Ashm.) were the most common of 9 parasites collected, the majority arriving 16 to 31 days after felling. The authors infer that the parasites arrive in response to some factor other than the bark beetle aggregation pheromone.
BIOLOGY, SEX RATIO, PARASITES, PHEROMONES, AGGREGATION PHEROMONES

33 Berisford, C.W.; Kulman, H.M.; Pienkowski, R.L.
1970. **Notes on the biologies of hymenopterous parasites of *Ips* spp. bark beetles in Virginia.** Can. Entomol. 102:484-490. 6 figs, 5 refs.
Presents biological data on 11 species of parasites associated with *Ips avulsus*, *I. grandicollis*, *I. calligraphus*, and *I. pini* in loblolly and white pines in Virginia.
BIOLOGY, PARASITES

34 Berisford, C.W.; Kulman, H.M.; Pienkowski, R.L.; Heikkenen, H.J.
1971. **Factors affecting distribution and abundance of hymenopterous parasites of *Ips* spp. bark beetles in Virginia (Coleoptera: Scolytidae).** Can. Entomol. 103:235-239. 1 tab, 3 figs, 5 refs.
Mass rearings of *Ips*-infested bolts from loblolly and white pines showed that parasitism was greatest in the upper boles, but no correlation with bark thickness was established. Parasitism was highest in overwintering broods. Rearings of individual larvae and pupae in gelatin capsules established 18 new host records for the 12 species of parasites collected from *Ips avulsus*, *I. calligraphus*, *I. grandicollis*, and *I. pini*.
REARING, BIOLOGY, PARASITES, HOST TREES

35 Berisford, C.W.; Franklin, R.T.
1971. **Attack patterns of *Ips avulsus* and *I. grandicollis* (Coleoptera: Scolytidae) on four species of southern pines.** Ann. Entomol. Soc. Am. 64:894-897. 4 figs, 17 refs.
Data from sticky traps on pines felled in northern Georgia during 1969 showed that *Ips avulsus* had a concentrated, 5-7 day attack period while *I. grandicollis* had a longer, less intense arrival. Hymenopterous parasites arrived about one week after the *Ips* adults. *I. avulsus* was abundant only on *Pinus echinata* and attacked within one day of felling. *I. grandicollis* was successful on all four pine species, commencing its attack of *P. taeda* and *P. palustris* 5-7 days after felling and *P. elliottii* 10-14 days after felling. Females and males of *I. avulsus* were captured in approx. equal numbers while *I. grandicollis* females were 1.7 times as numerous as males.
SEX RATIO, PARASITES, ATTACK BEHAVIOR, HOST TREES

36 Berisford, C.W.; Franklin, R.T.
1972. **Tree host influence on some parasites of *Ips* spp. bark beetles (Coleoptera: Scolytidae) on four species of southern pines.** J. Ga. Entomol. Soc. 7:110-115. 1 tab, 2 figs, 10 refs.
Sticky trap data showing the arrival densities of *Ips avulsus*, *I. grandicollis*, and various hymenopterous parasites to four *Pinus* species indicate that the parasites are strongly influenced by the host species and that different *Ips* species have little effect.
PARASITES, PREDATORS

37 Berisford, C.W.
1974. **Parasite abundance in *Ips* spp. infestations as influenced by the southern pine beetle.** Environ. Entomol. 3:695-696. 2 figs, 7 refs.
Six species of hymenopterous parasites and two species of clerid predators were found to be differentially attracted to pines infested with *Ips* beetles within and outside of *Dendroctonus frontalis* infestations.
PARASITES, PREDATORS

38 Berisford, C.W.; Brady, U.E.
1976. **Duration of protection of loblolly pines from *Ips* bark beetles by lindane.** J. Econ. Entomol. 69:357-358. 2 figs, 5 refs.
A 0.5% lindane-water emulsion was applied to standing *Pinus taeda* in northern Georgia in August 1974. Lindane bark residues decreased from an initial 67 ppm to 12 ppm after one year. *Ips* attacks on trees felled at monthly intervals were unsuccessful until residues fell below 30 ppm 7 months after treatment.
CHEMICAL CONTROL, LINDANE

39 Bess, H.A.
1944. **Insect attack and damage to white-pine timber after the 1938 hurricane in New England.** J. For. 42:14-16.
Insects killed few of the trees which remained standing after the 21 September 1938 hurricane in New England. *Ips calligraphus* was one of the less common bark beetles infesting wind-thrown *Pinus strobus*, being abundant in only a few localities.
PHYSICAL FACTORS, HURRICANES, DAMAGE, APPLIED CONTROL, CHEMICAL CONTROL

40 Billings, R.F.
1972. **Scolytidae collected in pine forests of British Honduras, Guatemala, and Honduras.** Pages 223-228 in "The Pine Forests of Central America." Turrialba, Costa Rica: Organization for Tropical Studies; 1972; Course No. 72-2 Final Rep. 575 p.
An annotated list of Scolytidae caught in barrier traps or collected from infested host material at several sites during one 2-week period in each country. *Ips calligraphus* [*I. interstitialis* (Eichh.)] was found in the lower boles of standing trees and freshly felled *Pinus caribaea* in British Honduras (Belize) and in freshly felled *P. oocarpa* in Honduras. *I. cribricollis* (Eichh.) [*I. grandicollis* (Eichh.)] occurred in the upper boles at these same sites and also in freshly felled *P. pseudostrobus* and *P. montezumae* in Guatemala.
DISTRIBUTION, HOST TREES

41 Billings, R.F.
1972. **Colonization patterns of two species of *Ips* (Coleoptera: Scolytidae) co-inhabiting pines in British Honduras and Honduras.** Pages 229-240 in "The Pine Forests of Central America." Turrialba, Costa Rica: Organization for Tropical Studies; 1972; Course No. 72-2 Final Rep. 575 p.
*Ips calligraphus* [=*I. interstitialis* (Eichhoff)] was the first species to respond to felled *Pinus caribaea* and *P. oocarpa* and its greatest attack densities were in the thick-bark region of the lower bole. Peak attack by *I. cribricollis* (Eichh.) [=*I. grandicollis* (Eichh.)] was a few days later and was confined to the branches and thin bark of the upper bole. The upper surfaces of horizontal stems were colonized only where there was thick bark or shade.
DISTRIBUTION, COMPETITION

42 Birch, M.C.
1978. **Chemical communication in pine bark beetles.** Am. Sci. 66:409-419. 9 figs, 57 refs.
A review of research into multicomponent pheromonal interactions of bark beetles which illustrates the diversity and scope of chemical communication. The interactions among the three *Ips* and two *Dendroctonus* species on *Pinus taeda* is one of the examples discussed.

REVIEW, PHEROMONES, ALLOMONES, KAIROMONES, SEMIOCHEMICALS

43 Birch, M.C.; Švihra, P.
1979. **Exploiting olfactory interactions between species of Scolytidae.** Pages 135-138, in Current Topics in Forest Entomology. W. E. Waters ed.). Selected Papers from the XVth International Congress of Entomology, Washington, D.C. August 1976. U. S. For. Serv. Gen. Tech. Rep. WO-8.
A brief report of research on attack sequence and distribution of three *Ips* and two *Dendroctonus* species on *Pinus taeda* in East Texas. Also reports on interactions between *I. grandicollis* and *D. frontalis*. [See also Birch et al. 1980 and Svihra et al. 1980.]
ATTACK, PHEROMONES, ATTRACTION, INHIBITION

44 Birch, M.C.; Švihra, P.; Paine, T.D.; Miller, J.C.
1980. **Influence of chemically mediated behavior on host tree colonization by four cohabiting species of bark beetles.** J. Chem. Ecol. 6:395-414. 11 tabs, 23 refs.
Presents data supporting the hypothesis that chemically mediated behavioral interactions play a significant role in defining the colonization of *Pinus taeda* by *Dendroctonus frontalis* and the three *Ips* species.
PHEROMONES, ATTRACTION, COLONIZATION, INHIBITION, INTERRUPTION

45 Blackman, M.W.
1919. **Notes on forest insects. 1. On two bark-beetles attacking the trunks of white pine trees.** Psyche 26(4):85-96. 1 fig, 2 refs, 1 plate.
Describes the biologies of *Ips longidens* Swaine [ = *Ips latidens* (LeConte)] and *Hylurgops pinifex* (Fitch). *Ips calligraphus* is mentioned as a frequent associate of *H. pinifex*.
ASSOCIATES

46 Blackman, M.W.
1922. **Mississippi bark beetles.** Miss. Agr. Exp. Stn. Tech. Bull. 11. 130 p. 18 plates, 1 map.
Contains keys to and discussions of the subfamilies, genera, and species of bark beetles found in Mississippi. Attack symptoms, adult and larval galleries, damage, and control methods are described on pages 57-58 for *Dendroctonus terebrans* and on pages 111-114 for the three *Ips* species.
LIFE HISTORY, HOST TREES, APPLIED CONTROL

47 Blake, G.H., Jr.
1956. **Control of black turpentine beetle in pine trees.** Page 55 in 64th and 65th Annu. Reports, January 1, 1953 - December 31, 1954. Agric. Exp. Stn., Alabama Polytechnic Inst., Auburn, Ala.
A spray containing 1 lb. of 25% wettable lindane and 4 lbs. of 50% wettable DDT in 50 gallons of water prevented additional black turpentine beetle attacks on infested trees for about 3 months. Sprays were applied to height of 25-30 feet.
CHEMICAL CONTROL

48 Blanford, W.F.H.
1897. **Family Scolytidae.** Pages 81-298 and plates 4-9 in Sharp, D., W.F.H. Blandford, and M.A.L. Jordan. Biologia Centrali-Americana. Insecta. Coleoptera. Vol. 4, pt. 6.
Lists (pp. 146-147) *Dendroctonus terebrans* [ = *D. valens* LeConte] as one of three *Dendroctonus* species occurring in Central America. The author noted that specimens from Guatemala and Mexico are similar to the Texas specimen labeled *D. terebrans* (Oliv.) in the Chapuis collection except that the latter is smaller and pitchy black in color.
DISTRIBUTION

49 Blatchley, W.S.; Leng, C.W.
1916. **Rhynchophora or weevils of North Eastern America.** Indianapolis: Nature Publ. Co. 682 p.
Contains identification keys and brief biological notes on the species of Brenthidae, Anthribidae, Curculionidae, and Scolytidae in eastern North America. Eight *Ips* species, including *I. avulsus*, *I. grandicollis*, and *I. calligraphus*, are included on pages 637-640, and *Dendroctonus terebrans* is one of six *Dendroctonus* species covered on pages 652-655.
TAXONOMY, HOST TREES, GEOGRAPHIC DISTRIBUTION

50 Borden, J.H.; Stokkink, E.
1971. **Secondary attraction in the Scolytidae: An annotated bibliography.** For Res. Lab., Can. For. Serv., Victoria, B. C. Inf. Rep. BC-X-57, 77 p.
Contains 172 annotated references indexed by author, species, and subject. [See Borden 1982 for the third edition of this bibliography.]
BIBLIOGRAPHY, PHEROMONES, SEMIOCHEMICALS

51 Borden, J.H.
1974. **Aggregation pheromones in the Scolytidae.** Pages 135-160 in Birch, M.C. (Ed.), Pheromones. Amsterdam: North-Holland Publ. Co. 495 p.
A review of the role of aggregation pheromones in host selection and mass attack by scolytids and the role of these pheromones in the host selection by predacious, parasitic, and commensal insect associates of the scolytids. *Ips grandicollis* and *I. calligraphus* are two of the species cited as examples of various processes.
REVIEW, PHEROMONES, AGGREGATION PHEROMONES, BEHAVIOR, ATTACK, FLIGHT, HOST FINDING, KAIROMONES

52 Borden, J.H.; Vandersar, T.J.; Stokkink, E.
1975. **Secondary attraction in the Scolytidae: An annotated bibliography.** Burnaby, B.C., Canada: Simon Fraser Univ., Dept. Biol. Sci. Pest Mgt. Pap. No. 4. v + 97 p.
This revision of the 1971 bibliography contains 309 references with author, taxonomic, and subject indices. [See Borden 1982 for the third edition of this bibliography.]
BIBLIOGRAPHY, PHEROMONES, SEMIOCHEMICALS

53 Borden, J.H.
1982. **Secondary attraction in the Scolytidae: An annotated bibliography.** Burnaby, B.C., Canada: Simon Fraser Univ., Dept. Biol. Sci., Pest Mgt. Pap. No. 26. v + 185 p.
This third edition of the bibliography contains 704 references for publications dated through December, 1980. The index shows 4 references to *Dendroctonus terebrans*, 13 to *Ips avulsus*, 13 to *I. calligraphus*, and 23 to *I. grandicollis*.
BIBLIOGRAPHY, PHEROMONES, SEMIOCHEMICALS

54 Brand, J.M.; Bracke, J.W.; Markovetz, A.J.; Wood, D.L.; Browne, L.E.
1975. **Production of verbenol pheromone by a bacterium isolated from bark beetles.** Nature 254:136-137.
Laboratory studies with microorganisms isolated from the hindgut of *Ips paraconfusus* showed that the bacterium *Bacillus cereus* can transform alpha-pinene into cis- and trans-verbenol. A *Bacillus* species isolated from *I. grandicollis* and 3 species of *Dendroctonus* is also capable of making this same transformation. The authors suggest that microorganisms may play a significant role in the synthesis of certain bark beetle pheromones.
PHEROMONE PRODUCTION, BACTERIA, ALPHA-PINENE, VERBENOL, MYRTENOL

55 Bridges, J.R.
1978. **Nitrogen-fixing bacteria associated with bark beetles.** Abstr. Annual Meeting, Am. Soc. Microbiol. 78:85.
Reports the isolation of nitrogen-fixing bacteria from *Dendroctonus frontalis, D. terebrans, Ips avulsus*, and *I. calligraphus*.
MICROORGANISMS, SYMBIONTS

56 Bridges, J.R.
1981. **Nitrogen-fixing bacteria associated with bark beetles.** Microb. Ecol. 7:131-137. 2 tabs, 31 refs.
The constant occurrence of large populations of *Enterobacter agglomerans* and *Enterobacter* spp. in black turpentine beetle larvae suggests a symbiotic relationship between the organisms. Nitrogen-fixing bacteria were not abundant in *Ips avulsus* and the southern pine beetle and may have been only chance contaminants.
MICROORGANISMS, SYMBIOSIS

57 Bright, D.E., Jr.
1972. **The Scolytidae and Platypodidae of Jamaica (Coleoptera).** Bull. Inst. Jam. Sci. Ser. No. 21. 108 p.
*Ips calligraphus* is the only *Ips* species recorded on the island of Jamaica where it infests *Pinus caribaea*.
TAXONOMY, IDENTIFICATION

58 Bright, D.E., Jr.; Stark, R.W.
1973. **Bark and ambrosia beetles of California. Coleoptera: Scolytidae and Platypodidae.** Bull. Calif. Insect Surv. 16. 169 p.
Provides keys to and briefly summarizes the taxonomic history, geographic range, host plants, biology, and economic importance of more than 170 species in California. *Ips calligraphus calligraphus* occurs at lower elevations in the Sierra Nevada Mountains, occasionally infesting apparently healthy ponderosa pines, but most frequently breeding in logging debris and recently felled trees (pages 83, 85, 90-91, 121).
TAXONOMY, BIOLOGY, DISTRIBUTION, HOST TREES

59 Bright, D.E., Jr.
1976. **The insects and arachnids of Canada — part 2. The bark beetles of Canada and Alaska. Coleoptera: Scolytidae.** Can. Dep. Agric. Publ. 1576. 241 p. 192 figs, 95 maps.
Contains keys to 214 species of bark beetles and information on adult morphology, host plants, distribution, and biology. *Ips calligraphus* and *I. grandicollis* (pp. 165-167) occur in eastern Canada.
BIOLOGY, IDENTIFICATION, HOST TREES, DISTRIBUTION

60 Bright, D.E., Jr.
1982. **Studies of West-Indian Scolytidae. 2. New distribution records and descriptions of a new genus and species.** Stud. Neotrop. Fauna Environ. 17:163-168.
Records the occurrence of *Ips avulsus* and *I. grandicollis* in the West Indies.
TAXONOMY, DISTRIBUTION

61 Brimblecombe, A.R.
1953. **An annotated list of the Scolytidae occurring in Australia.** Queensl. J. Agric. Sci. 10:167-205. 18 figs, 17 refs.
*Ips grandicollis* is one of 92 species of Scolytidae occurring in Australia. It was found only in the state of South Australia infesting *Pinus nigra, P. halepensis*, and *P. radiata*. The author cites Swan (1950, unpublished report) as the source for his statement that it was first found in 1943, but caused no serious damage until 1950.
DISTRIBUTION, HOST TREES

62 Britton, W.E.; Zappe, M.P.
1922. **Miscellaneous insect notes.** Conn. Agric. Exp. Stn., New Haven, Bull. 234:194-202.
A brief report (p. 196) that *Ips calligraphus* was found in a large, dead white pine in Putnam, Connecticut in August, 1921.
OUTBREAK

63 Brower, J.H.
1974. **Developmental success of two species of *Ips* (Coleoptera: Scolytidae) in a chronically irradiated forest community.** Can. Entomol. 106:233-238. 4 figs, 10 refs.
*Ips grandicollis* and *I. calligraphus* attack densities on dying, irradiated *Pinus rigida* were not affected by radiation intensity. Parent beetles were killed before ovipositing where dosages exceeded 500 r/day, and brood developed normally where exposed to less than 25 r/day.
PHYSIOLOGY, GROWTH, RADIATION EFFECTS, GAMMA RADIATION

64 Brower, J.H.
1977. **Effects of chronic gamma radiation on populations of *Ips* (Coleoptera: Scolytidae) in trap logs.** Ecol. Entomol. 2:105-112. 1 tab, 4 figs, 29 refs.
Experiments using trap logs showed that the developmental success of *Ips calligraphus* and *I. grandicollis* broods was related to the radiation dose rate. The author speculates that nuclear fallout would debilitate radiation sensitive conifers and trigger epidemic increases in bark beetle populations.
PHYSIOLOGY, GROWTH, RADIATION EFFECTS, GAMMA RADIATION

65 Browne, F.G.
1968. **Pests and diseases of forest plantation trees.** Oxford: Clarendon Press. 1330 p.
An annotated list of the principal pests of forest trees in the British Commonwealth, including brief summaries of the distributions and biologies of *Ips calligraphus* and *I. grandicollis* (pages 363, 365).
BIOLOGY, DISTRIBUTION, DAMAGE

66 Browne, F.G.
1977. **Additions to the Scolytid fauna (Coleoptera: Scolytidae) of the Philippines.** Philipp. J. Sci. 106:85-86. 2 refs.
Reports that *Ips interstitialis* (Eichhoff) [ = *I. calligraphus* (Germar) sensu S. L. Wood 1982] is established in Luzon, Philippines.
TAXONOMY, BIOLOGY, DISTRIBUTION

67 Bungey, R.S.
1966. **The biology, behaviour and chemical control of *Ips grandicollis* (Eichh.) in pine slash.** Australia: Univ. of Adelaide. M. Agr. Sci. Thesis.
Not seen. Thesis cited by Witanachchi (1980a).
BIOLOGY, BEHAVIOR, CHEMICAL CONTROL

68 Burks, B.D.
1979. **Catalog of Hymenoptera in America north of Mexico. Family Pteromalidae.** Pages 768-835 in Karl V. Krombein et al., Catalog of Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, DC. 2735 pages in 3 volumes.
Confirmed Pteromalid parasites are *Dinotiscus [Cecidostiba] dendroctoni* (Ashmead) for *Ips grandicollis* and *Tomicobia tibialis* Ashmead for *I. grandicollis* and *I. calligraphus*.
PARASITES

69 Bushing, R.W.
1965. **A synoptic list of the parasites of Scolytidae (Coleoptera) in North America north of Mexico.** Can. Entomol. 97:449-492. 183 refs.
Lists two, five, and seven hymenopterous parasites for *Ips avulsus*, *I. calligraphus*, and *I. grandicollis*, respectively.
BIOLOGY, PARASITES

70 Butcher, T.B.; Havel, J.J.
1976. **Influence of moisture relationships on thinning practice.** N. Z. J. For. Sci. 6:158-170. 1 tab, 15 figs, 7 refs.
Suggests precommercial thinning or planting at wider spacings as practices for reducing summer moisture stress and *Ips grandicollis* infestations in *Pinus pinaster* and *P. radiata* in western Australia.
STRESS, STAND CONDITIONS, CULTURAL CONTROL

71 Chamberlin, W.J.
1939. **The bark and timber beetles of North America.** Corvallis: Oreg. State Coll. Coop. ASSoc. 513 P.
Contains information on the taxonomy, biology, and control of 72 genera and 575 species of the superfamily Scolytoidea. In addition to keys to families, subfamilies, genera, and species, each species is annotated with a brief description of the adult, type locality, distribution, hosts, and habits. *Dendroctonus terebrans* is discussed on p. 167 and *Ips calligraphus*, *I. grandicollis*, and *I. avulsus* on pages 416, 417, and 425, respectively. The extensive bibliography, pp. 471-500, is a particularly useful reference to the older literature.
TAXONOMY, BIOLOGY, DISTRIBUTION, HOST TREES

72 Chapman, H.H.; Friend, R.B.
1942. **Management of loblolly pine in the pine-hardwood region in Arkansas and in Louisiana west of the Mississippi river.** Yale Univ. Sch. For. Bull. No. 49:145.
Briefly mentions *Ips* spp. and *Dendroctonus terebrans* as secondary pests of loblolly pine (p. 145).
DAMAGE

73 Chapuis, F.
1869. **Synopsis des Scolytides.** Liege. 61 pp.
Preprint of Chapuis 1873 and cited by taxonomists as the original publication for the new species described in both publications.
TAXONOMY

74 Chapuis, F.
1873. **Synopsis des Scolytides.** Memoires de la Societe Royale Des Sciences de Leige 3(2):213-269.
Contains Latin descriptions of *Dendroctonus terebrans* specimens from Texas and *D. valens* specimens from California, Oregon, and New York (pp. 243-244).
TAXONOMY,

75 Chellman, C.W.
1980. **Tree mortality (pest) surveys in Florida from 1959 thru 1979.** Forest pest management symposium, Florida Section, Society of American Foresters, 3-4 June 1980. Gainesville, FL: Univ. Fl. School of Forest Resources and Conservation Resources Report 7:8-12. 2 tabs, 1 fig.
Aerial survey data over a 20-year period indicate a generally increasing trend in annual pine tree mortality. *Ips* engraver beetles were the most serious insect problem, particularly in crowded stands growing on dryer sites. The black turpentine beetle, fusiform rust, and pitch canker were also serious problems.
SURVEYS, DAMAGE, OUTBREAK

76 Chittenden, F.H.
1899. **Insect enemies of the white pine.** U. S. Dep. Agr. Div. For. Bull. 22:55-61. 11 figs.
*Dendroctonus terebrans* (including *D. valens*) is reported as occurring in much of the United States and Canada and as infesting all species of pines. The author states that *Tomicus cacographus* [*Ips grandicollis*] occurs on *Pinus strobus* in the southern range of this tree, *T. calligraphus* abounds in the North and the South, and *T. avulsus* also infests white pine.
DAMAGE

77 Cibulsky, R.J.; Hyche, L.L.
1974. ***Ips* spp.: Effect of dichlorvos-fuel oil sprays.** J. Econ. Entomol. 67:678-680. 3 tabs, 9 refs.
Dichlorvos at 1/16% concentration in No. 2 fuel oil was as effective as a 1/4% BHC-fuel oil treatment for controlling *Ips* spp. in loblolly pine bolts. Fuel oil alone also resulted in considerable mortality of bark beetles and associated insects.
PARASITES, CHEMICAL CONTROL, FUEL OIL, DICHLORVOS, BHC

78 Cibulsky, R.J.; Hyche, L.L.
1977. **Dichlorvos: Effective against *Ips* engraver beetles.** Auburn, AL: Auburn Univ. Agric. Exp. Stn., Highlights Agric. Res. 24:1 3.
Popular article based on data in Cibulsky and Hyche (1974).
PARASITES, CHEMICAL CONTROL, FUEL OIL, DICHLORVOS, BHC

79 Ciesla, W.M.; Bell, J.C., Jr.
1968. **The pine engraver, *Ips pini* (Coleoptera: Scolytidae), in the southern Appalachian Mountains.** Ann. Entomol. Soc. Am. 61:235-236. 1 fig, 3 refs.
Reports the occurrence of *Ips pini* as a secondary invader of *Pinus strobus* and *P. virginiana* in Tennessee, North Carolina, and South Carolina. Its occurrence in Virginia pine followed an aggressive infestation of *I. grandicollis*. *Dendroctonus terebrans* is listed as one of the common scolytid associates of *I. pini*.
DISTRIBUTION, HOST TREES, BIOLOGY, FUNGI

80 Ciesla, W.M.
1969. **Insect hazards of natural disasters.** South. Lumberman 219:188-189.
Briefly discusses *Ips* spp. and the black turpentine beetle as potential hazards in pine stands damaged by natural disaster and presents broad guidelines for timber salvage.
PHYSICAL FACTORS, OUTBREAK, CULTURAL CONTROL, APPLIED CONTROL, HURRICANES, TORNADOES, ICE STORMS

81 Ciesla, W.M.
1973. **Six-spined engraver beetle.** U. S. For. Serv. For. Pest Leafl. 141. 6 p. 5 figs, 5 refs.
Provides information on distribution and hosts, evidence of infestation, life history and habits, natural control, prevention, and direct control of *Ips calligraphus*.
REVIEW, BIOLOGY

82 Clark, E.W.; Osgood, E.A., Jr.
1964. **Mass rearing the southern pine beetle and the coarse writing engraver.** U. S. For. Serv. Res. Note SE-30. 4 p. 1 fig.
Discusses techniques and precautions for mass rearing *Ips calligraphus* and *Dendroctonus frontalis* on fresh pine bolts in 20-gallon trash cans.
REARING

83 Clark, E.W.; Osgood, E.A., Jr.

1964. **A simple laboratory technique for rearing *Ips calligraphus*.** U. S. For. Serv. Res. Note SE-31. 3 p. 2 figs, 1 ref.

*Ips calligraphus* adults were introduced into screened cages containing pine bolts aged 3 to 5 days. Brood adults emerged about 45 days later. A lard-can emergence container is also described.

REARING

84 Clark, E.W.; Osgood, E.A., Jr.

1964. **An emergence container for recovering southern pine beetles from infested bolts.** J. Econ. Entomol. 57:783-784. 1 fig.

Describes the construction of a 20-gallon container for collecting bark beetle adults emerging from infested material.

REARING

85 Clark, E.W.

1965. **An artificial diet for the southern pine beetle and other bark beetles.** U. S. For. Serv. Res. Note SE-45. 3 p. 1 fig, 6 refs.

Reports an artificial medium on which egg to adult survival of *Dendroctonus frontalis* was 20%. *Ips calligraphus*, pales weevil, cerambycids, and buprestids were also reared on the medium.

REARING, ARTIFICIAL DIET

86 Clark, E.W.; Osgood, E.A., Jr.

1966. **Southern pine beetles.** Pages 305-310 in C.N. Smith, ed. Insect Colonization and Mass Production. N.Y.: Academic Press. 618 p.

Provides additional information on the previously described technique for the mass rearing of southern pine bark beetles on pine bolts in 20-gallon containers.

REARING

87 Clark, E.W.

1970. **Attack height of the black turpentine beetle.** J. Ga. Entomol. Soc. 5:151-152. 5 refs.

Describes an unusual instance of initial *Dendroctonus terebrans* attacks on a loblolly pine occurring 15-20 feet above the ground and total attack height reaching to 55 feet. *Ips grandicollis* attacked the tree above the 55-foot height.

BEHAVIOR, ATTACK

88 Clark, E.W.

1978. **Beetle problems in southern pines in oleoresin production.** International Union of For. Res. Organizations: Meeting of IUFRO Working Groups S 2.06.12 and 2.07.07 Pests and Diseases of Tropical Pines. 'Piedras Blancas,' Medellin, Columbia, September 3-14, 1978.

Reviews how the method of paraquat application, paraquat dosage and concentration, season of application, and weather affect bark beetle colonization of trees treated for lightwood production.

PHYSICAL FACTORS, WEATHER, CHEMICAL CONTROL, LIGHTWOOD INDUCTION, IPM, PARAQUAT

89 Clason, T.R.

1978. **Utilization of paraquat in a silvicultural thinning regime: First year results.** Pages 14-18 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.

Bark-beetles attacked 31 of 42 paraquat-treated loblolly pines, but caused no tree mortality in the 8 months following the treatment. Bark beetles did not attack adjacent, untreated trees.

PARAQUAT, LIGHTWOOD INDUCTION

90 Clason, T.R.

1979. **Paraquat induced oleoresin biogenesis in a thinned loblolly pine stand: Second year results.** Pages 104-106 in Esser, M.H., ed. Sixth Annu. Lightwood Res. Conf. Proc.; 1979 January 17-18; Atlanta, Ga. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 151 p.

Bark beetles were contributing factors in the deaths of eight of 12 paraquat-treated trees which died in 1978. Oleoresin yield decreased in proportion to the amount of blue stain present in the trees.

FUNGI, TREE MORTALITY, LIGHTWOOD INDUCTION, PARAQUAT, BLUE STAIN FUNGI, TREE GROWTH

91 Clemens, W.A.

1916. **The pine bark beetle.** Cornell Univ. Agric. Expt. Sta., Ithaca, N.Y., Bull. 383, Oct. 1916, PP. 385-398. 4 figs, 2 plates, 8 refs.

*Ips calligraphus* is listed as one of the beetles commonly found in trees infested by *I. pini*.

ASSOCIATES

92 Clements, R.W.

1974. **Modern gum naval stores methods.** U. S. For. Serv. Gen. Tech. Rep. SE-7. 29 p.

Briefly describes the mixing and application of 1% lindane or BHC water emulsions or fuel oil solutions for *Dendroctonus terebrans* and *Ips* spp. in gum naval stores stands.

CHEMICAL CONTROL

93 Clements, R.W.; Williams, H.G.

1981. **Attractants, techniques, and devices for trapping bark beetles.** U. S. For. Serv. Res. Note SE-309. 3 P.

Describes a trap consisting of a stovepipe in a water-filled catch basin and using spirits of turpentine as the attractant. Thousands of *Dendroctonus terebrans* and *Ips* spp. were trapped in south Georgia trials.

TRAPS, ATTRACTANTS, TURPENTINE

94 Coleman, R.V.

1977. **The black turpentine beetle and its control.** Ga. Coop. Ext. Serv. Circ. 404. 12 p. 10 figs.

A particularly well-illustrated extension brochure.

LIFE HISTORY, CHEMICAL CONTROL, DAMAGE

95 Cook, S.P.; Wagner, T.L.; Flamm, R.O.; Dickens, J.C.; Coulson, R.N.

1983. **Examination of sex ratios and mating habits of *Ips avulsus* and *I. calligraphus* (Coleoptera: Scolytidae).** Ann. Entomol. Soc. Am. 76:56-60. 1 tab, 2 figs, 26 refs.

Emergence traps on *Pinus taeda* in east Texas indicated ca. 1:1 sex ratios (male:female) for emerging broods of *Ips avulsus* and *I. calligraphus*, a 1:1 ratio for reemerging *I. avulsus* parent adults, and a 1:3 ratio for reemerging *I. calligraphus*. Dissection of bark samples indicated ca. 3 egg galleries per nuptial chamber for both species. Radiographs of bark slabs showed that the discrepancy between *I. avulsus* reemergence and egg gallery ratios were due to males frequently pairing off with females in the egg galleries, leaving the nuptial chamber open for other beetles.

SEX RATIO, MATING

96 Cooper, J.W.

1955. **Black turpentine beetle can be controlled.** AT-FA Journal 18:8-9.

A general, informative article stressing control of *Dendroctonus terebrans* in gum naval stores operations. Chemical control of *Ips* spp. is mentioned briefly.

CHEMICAL CONTROL, BEHAVIOR

97 Cory, E.N.

1914. **Entomological features of the year 1913, and some work undertaken for the control of injurious insects.** Rept. Maryland State Hortic. Soc. 16:168-170.

Reports that *Ips grandicollis* damaged Koster blue spruces (*Picea pungens*) in a nursery.

OUTBREAK

98 Craighead, F.C.; Middleton, W.

1930. **An annotated list of the important North American forest insects.** U.S. Dep. Agric. Misc. Publ. 74. 30 p., 89 refs.

States (p. 4) that *Dendroctonus terebrans* rarely kill trees and are important "more as a result of the attention they attract than because of the damage inflicted." Sporadic outbreaks of the *Ips* engraver beetles often follow drought, windfalls, and slashings (p.6).

DISTRIBUTION, DAMAGE, HOST TREES

99 Craighead, F.C.

1935. **Insects that attack southern pines.** Pages 132-141 in A Naval Stores Handbook Dealing with the Production of Pine Gum or Oleoresin. U. S. Dep. Agric. Misc. Publ. 209. 201 p.

States that losses to slash and longleaf pine due to the 3 *Ips* species are greatest during periods of severe drought. Occasionally they are injurious around logging operations, breeding in the slash and becoming abundant enough to kill standing trees. The black turpentine beetle "seldom, if ever, kills trees."

ATTACK, DAMAGE, STAND CONDITIONS, DROUGHT

100 Craighead, F.C.

1950. **Insect enemies of eastern forests.** U. S. Dep. Agr. Misc. Publ. 657. 679 p.

Discusses the general habits and economic importance of bark beetles beginning on page 294. Presents a nontechnical key for identifying the work of many eastern bark beetles on pages 302-308. *Dendroctonus terebrans* and the *Ips* species are discussed briefly on pages 320 and 334-335, respectively.

BIOLOGY, DAMAGE

101 Cross, E.A.; Moser, J.C.

1971. **Taxonomy and biology of some Pyemotidae (Acarina: Tarsonemoidea) inhabiting bark beetle galleries in North American conifers.** Acarologia 13:47-64. 18 figs, 11 refs.

Describes three new species of mites. One species, *Pygmephorus (Pygmephorellus) bennetti*, was found associated with *Ips avulsus, I. grandicollis*, and *I. calligraphus*. Another mite, *P. brachycercus*, was found in a lightning-struck longleaf pine infested by *I. calligraphus.*

MITES

102 Cross, J.K.

1953. **Successful fight being waged with turpentine beetle.** South. Lumberman 187(2339):34; Sept. 15, 1953.

A popular-style article relating the experiences of several naval stores operations in combating the black turpentine beetle with their own formulation of a wettable BHC powder in kerosene.

CHEMICAL CONTROL

103 Currie, R.P.

1905. **Catalogue of the exhibit of economic entomology at the Lewis and Clark centennial exposition, Portland, Oregon, 1905.** U. S. Dep. Agric. Div. Entomol. Bull. 53. 127 p.

Page 100 has a brief description of the adults and work of *Ips avulsus* which were exhibited at the Lewis and Clark Centennial Exposition.

ADULTS, GALLERIES

104 Dale, J.W.

1967. **The influence of temperature on the population growth of three species of southern pine engravers.** Durham, NC: Duke Univ. Sch. of Forestry. xi + 137 p. 32 tabs, 36 figs, 25 refs. Thesis.

Presents data on survivorship and developmental times for the three *Ips* species at 5 constant and 4 alternating temperature regimes from 20 to 37.5 deg. C. Most rapid developement occurred at 35 deg. C. and mean egg-to-emergence times were 19.3, 19.8, and 16.9 days for *Ips avulsus, I. grandicollis*, and *I. calligraphus*. Maxima for observed fecundity were 109, 206, and 274 eggs, respectively.

DEVELOPMENT TIME, EGGS, LARVAE, PUPAE, ADULTS, SEX RATIO, FECUNDITY, REPRODUCTIVE POTENTIAL

105 Dejean, P.F.M.A.

1837. **Catalogue des Coleopteres de la collection de M. le Comte Dejean. 3rd ed.** Paris: Chez Mequignon-Marvis Pere et Fils. 503 p.

A listing of the species in Count Dejean's collection and the countries where they were collected. The specimens labeled *Bostrichus chloroticus* and *B. conformis* (p. 332) were recognized by Eichhoff (1878) as synonyms of *Ips calligraphus*.

TAXONOMY

106 Deyrup, M.A.

1981. **Annotated list of Indiana Scolytidae (Coleoptera).** Great Lakes Entomol. 14(1):1-9. 11 refs.

*Ips grandicollis* is reported from *Pinus strobus, P. sylvestris, P. banksiana*, and *P. virginiana* throughout Indiana. *Ips calligraphus* is recorded only from *P. sylvestris* in the northern portion of the state.

DISTRIBUTION, HOST TREES

107 Dietz, W.G.

1890. **Notes on the species of *Dendroctonus* of boreal America.** Trans. Am. Entomol. Soc. 17:28-32.

This description of *Dendroctonus terebrans* characters and distribution erroneously includes *D. valens* LeConte.

MORPHOLOGY, DISTRIBUTION

108 Dixon, W.N.; Payne, T.L.

1979. **Sequence of arrival and spatial distribution of entomophagous and associate insects on southern pine beetle-infested trees.** Tex. Agr. Exp. Stn. Misc. Publ. 1432. 2 tabs, 42 figs, 66 refs.

Presents data on the height and sequence of arrival plus the relative abundance of over 150 species of insects trapped on 7 *Dendroctonus frontalis*-infested pines in east Texas. Peak arrivals of *Ips avulsus. I. grandicollis*, and *I. calligraphus* were 12, 18, and 21 days after initiation of *D. frontalis* attacks, and maximum numbers were at the highest height sampled (12 meters). The absence of *D. terebrans* and the low numbers of *I. calligraphus* suggests these 2 species were able to walk off the sticky traps.

ASSOCIATES

109 Dixon, W.N.; Payne, T.L.

1980. **Attraction of entomophagous and associate insects of the southern pine beetle to beetle- and host tree-produced volatiles.** J. Ga. Entomol. Soc. 15:378-389. 3 tabs, 32 refs.

*Ips grandicollis* and *I. calligraphus* were among the 15 entomophagous and 13 associate insects attracted to wingtraps baited with several *Dendroctonus frontalis*- and host tree-produced volatiles.

PARASITES, PREDATORS, ASSOCIATES, PHEROMONES, SEMIOCHEMICALS, ATTRACTANTS, ALPHA-PINENE, FRONTALIN, VERBENOL, TURPENTINE, BREVICOMIN

110 Doane, R.W.; Van Dyke, E.C.; Chamberlin, W.J.; Burke, H.E.

1936. **Forest insects.** McGraw-Hill Book Co., N.Y., 463 p., illus.

Contains brief textbook summaries of the biologies, distributions, and hosts of many bark beetles including *Dendroctonus terebrans* (p. 84), *Ips calligraphus* (p. 85), *I. grandicollis* (p. 86-87), and *I. avulsus* (p. 92).

BIOLOGY, DISTRIBUTION, DAMAGE, HOST TREES

111 Dodge, H.R.

1938. **The bark beetles of Minnesota (Coleoptera: Scolytidae).** Minn. Agric. Exp. Stn. Tech. Bull. 132, 60 p., illus.

Discusses briefly the morphological characters, biology, and hosts and provides a key to the 7 then-recognized species of *Ips* occurring in Minnesota. *Ips calligraphus* and *I. grandicollis* breed in the various pine species throughout the state, the first species being an occasional primary pest.

MORPHOLOGY, BIOLOGY, HOST TREES

112 Doggett, C.A.

1973. **Field notes on ice damage in North Carolina.** N. C. For. Serv. Forestry Note 5. 4 p.

Even though *Ips grandicollis* was prevalent in broken tops following a February ice storm, subsequent tree mortality was very low in residual healthy trees.

PHYSICAL FACTORS, WEATHER, ICE STORMS

113 Dozier, H.L.

1920. **An ecological study of hammock and piney woods insects in Florida.** Ann. Entomol. Soc. Am. 13:325-380. 22 figs, 18 refs.

Presents an annotated list of over 300 species of insects collected in the hardwood hammocks and piney woods near Gainesville Florida in 1916 and 1917. The only scolytid reported is *Ips calligraphus* collected in August from a felled longleaf pine.

ECOLOGY

114 Draper, L.

1978. **First standard LRCC study — results.** Pages 96-100 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.

*Ips* beetles killed 3 and 13 percent of the trees in two tests of 8% paraquat, even though the trees were sprayed with lindane prior to and 1 to 2 months following the treatment.

DAMAGE, LIGHTWOOD INDUCTION, PARAQUAT

115 Drew, J.

1977. **Pine beetle attack as a result of paraquat treatment.** Pages 4-11 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1977 January 18-19; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 193 p.

A questionnaire survey of 26 companies indicated that *Ips* spp. and sometimes *Dendroctonus terebrans* were the major pests in slash pines treated for lightwood induction. *D. frontalis* was the major pest in loblolly pines. Insect attacks and tree mortality increased with increasing concentrations of paraquat and the severity of the wounding. Generally, tree mortality was negligible until 6 months following the treatment. Spring treatments had the highest mortality, fall treatments the least. Several insecticides reduced, but did not completely prevent, insect attacks and tree mortality.

DAMAGE, CHEMICAL CONTROL, LIGHTWOOD INDUCTION, PARAQUAT, BHC, LINDANE, DURSBAN, RELDAN, ORTHENE

116 Drew, J.

1978. **Bark beetles in paraquat treated pines.** Pages 70-81 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.

A second questionnaire survey confirmed the results noted in the first survey (see Drew 1977). New reports from pilot studies indicated that verbenone and trans-verbenol may inhibit *Ips* attacks on paraquat-treated trees. There were no reports of beetles spreading to and infesting adjacent untreated stands.

PHEROMONES, REPELLENTS, VERBENONE, TRANS-VERBENOL, DAMAGE, LIGHTWOOD INDUCTION, PARAQUAT, ETHREL

117 Eichhoff, W.

1868. **Neue amerikanische Borkenkafer-Gattungen und Arten.** Berliner Entomologische Zeitschrift 11:399-402. (Published Jan. 1868.).

Contains the original taxonomic descriptions, in Latin, for *Ips grandicollis* and *I. avulsus* as *Tomicus grandicollis* and *T. avulsus*, respectively. Also describes *T. praemorsus* which Eichhoff (1876) later recognized as a synonym of *I. calligraphus*.

TAXONOMY

118 Eichhoff, W.

1869. **Neue borkenkafer.** Berliner Entomologische Zeitschrift 12:273-282. (Published March 1869).

The original taxonomic descriptions for *Tomicus* [=*Ips*] *interstitialis* and *T. cribricollis.* Some taxonomists (Hopping 1965b, S. L. Wood 1977, 1982) consider these names as junior synonyms of *Ips calligraphus* and *I. grandicollis* although Lanier (1970, 1972) presents morphological and karyological data supporting the validity of these two species.

TAXONOMY

119 Eichhoff, W.

1876. **Synonymisches über Tomiciden.** Stettiner Entomologische Zeitung 37:378-379.

Among the 16 taxonomic synonymies noted in this paper, Eichhoff recognized his 1868 description of *Tomicus praemorsus* as a junior synonym of Germar's *Tomicus calligraphus*.

TAXONOMY

120 Eichhoff, W.

1878. **Ratio, descripto, emendatio eorum tomicinorum.** Memoires de la Societe Royale des Sciences de Liege, Ser. 2, Vol. 8. 531 p.

This monograph, written in Latin, describes the morphology of numerous scolytid species and Eichhoff's views on their relationships to one another. New synonyms for *Tomicus* [ = *Ips*] *calligraphus* are *Bostrichus conformis* DeJean (1837) and *B. chloroticus* DeJean (1837).

TAXONOMY

121 Eikenbary, R.D.; Coppock, S.

1974. **Field key to beetles in pines.** Okla. State Univ. Ext. Facts No. 7164. 4 p.

This extension paper has simple, illustrated keys for identifying adults and galleries of southern pine beetles, black turpentine beetles, *Ips* beetles, southern pine sawyers, turpentine borers, ambrosia beetles, and bostrichid beetles. Prevention and control of infestations are also discussed briefly.

IDENTIFICATION

122 Elliott, E.W.

1970. **Host selection by pioneer beetles of *Ips grandicollis* (Coleoptera: Scolytidae).** Durham, NC: Duke Univ. School of Forestry. xi + 109 p. 53 tabs, 13 figs, 104 refs. Thesis.

Describes experiments to determine the mechanism by which pioneer beetles of *Ips grandicollis* select host material. The author concludes that host selection occurs in response to odors emanating from the host. He suggests that factors other than odors may also be operative, and that the beetles must be very near the host before host recognition occurs.

HOST FINDING, SEMIOCHEMICALS

123 Erichson, W.F.

1836. **Systematische auseinandersetzung der familie der Borkenkafer (Bostrichidae). Systematic analysis of the bark beetle family Bostrichidae.** Archive fur Naturgeschichte 2(1):44-65.

Lists *Dendroctonus terebrans* as one of 5 species in the new genus *Dendroctonus*. [See Hopkins (1909a, p. 4) for a translation of Erichson's Latin description of the genus.]

TAXONOMY, MORPHOLOGY

124 Ericksen, W.D.

1978. **Results of the first standard LRCC study - loblolly pine in Nassau County, Florida.** Pages 105-109 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.

Contains information on bark beetle-caused tree mortality on loblolly pine up to 2 years after treatment with 4% and 8% paraquat aqueous solutions. Tree mortality was also observed to decrease with increased tree diameter.

TREE MORTALITY, LIGHTWOOD INDUCTION, PARAQUAT

125 Etheridge, D.E.

1971. **New pests and diseases of forest trees [in the Dominican Republic].** FAO Plant Prot. Bull. 19:21-22.

Reports *Ips calligraphus* infesting recently-felled and hurricane-damaged pines in the Dominican Republic.

OUTBREAK, HURRICANES

126 Fatzinger, C.W.; DeBarr, G.L.

1969. **How to distinguish attacks by the black turpentine beetle and *Dioryctria amatella* on southern pines.** U. S. For. Serv. Res. Note SE-101. 4 P. 3 figs.

A well-illustrated guide differentiating attack symptoms of the black turpentine beetle and southern pine coneworm with emphasis on pitch mass characteristics.

ATTACK

127 Feduccia, D.P.; Mann, W.F., Jr.

1975. **Black turpentine beetle infestations after thinning in a loblolly pine plantation.** U. S. For. Serv. Res. Note SO-206. 3 P. 1 tab, 3 refs.

This is a well-documented case of black turpentine beetle attack, tree mortality and the use of 0.5% lindane fuel oil spray following the thinning of a 22-year-old loblolly pine plantation in southwest Louisiana. BTB infestation was followed for two years on 88 plots of various thinning regimes and residual stand density. Simple recommendations are given for minimizing losses due to BTB following logging.

ATTACK, CHEMICAL CONTROL, STAND CONDITIONS, TREE MORTALITY, SITE FACTORS, THINNING, LOGGING

128 Felt, E.P.

1902. **Observations on forest and shade tree insects in New York state.** U. S. Dep. Agr. Div. Entomol. Bull. 31:63-68.

*Tomicus* [ = *Ips*] *calligraphus* attacked apparently healthy white pines near Albany, N.Y. in 1901. *T. cacographus* [ = *I. grandicollis*], along with other *Ips* species, killed hard pines over a large area on Long Island. *Dendroctonus terebrans* also infested pines in these two areas [Hopkins (1909a) considered the beetles near Albany to be *D. valens* LeConte].

BIOLOGY, OUTBREAK

129 Felt, E.P.

1903. **Insects affecting forest trees.** Forest, Fish and Game Comm. State N. Y. Rep. 7, pp. 480-481. 2 plates, 3 figs.

Not seen. According to Hopkins (1909a, p. 157), *Dendroctonus terebrans* occurs only in the Long Island area of New York and the information for the remainder of the state properly pertains to *D. valens*.

130 Felt, E.P.

1906. **Insects affecting park and woodland trees.** N.Y. State Mus. Mem. 8, 1:1-322; 2:333-887.

Summarizes the life histories, habits, distributions, and natural enemies of *Dendroctonus terebrans* [including *D. valens*], *Ips calligraphus*, and *I. grandicollis* in New York state. Contains interesting narratives and photographs based on the author's experiences.

LIFE HISTORY, HOST TREES

131 Felt, E.P.

1924. **Manual of tree and shrub insects.** New York: MacMillan Co. xxvi + 382 p.

Pages 262-266 contain brief accounts regarding the habits of *Dendroctonus terebrans*, *Ips calligraphus*, and *I. grandicollis* (as *I. cacographus* LeConte) in New York.

BIOLOGY, DAMAGE

132 Felt, E.P.; Bromley, S.W.

1942. **The increasing importance of coleoptera borers in shade trees.** J. Econ. Entomol. 35(2):169-171.

Reports the apparent increase in shade tree borers following a series of unusual weather conditions in southern New England. *Dendroctonus terebrans* and *D. valens* increased on pitch pines on Cape Cod, Massachusetts. *Ips calligraphus* and *I. grandicollis* are listed among the insects attacking hurricane-damaged pines.

OUTBREAK, PHYSICAL FACTORS, HURRICANES, DROUGHT

133 Felt, E.P.; Bromley, S.W.

1944. **The insect menace to shade trees in the Northeast.** J. Econ. Entomol. 37(2):212-213.

*Dendroctonus terebrans* and *D. valens* attacked pitch pines on Cape Cod, particularly where trees were disturbed by construction of buildings. Beetles were also attracted to pines near freshly painted homes. A lime sulfur wash applied to the basal 1 m of trees was promising as a beetle deterrent or repellent.

ATTRACTANTS, DAMAGE, CHEMICAL CONTROL

134 Fitch, Asa.

1858. **Fourth report on the noxious and other insects of the state of New York. Insects infesting evergreen forest trees.** Trans. New York State Agr. Soc. 17:687-753.

Briefly describes (pp. 721-722) habits of *Tomicus* [ = *Ips*] *calligraphus*, principally on pitch pine and branches of white pine. [The description for *Hylurgus (Dendroctonus) terebrans* (pp. 728-729) is obviously a description of the red turpentine beetle, *D. valens* LeConte.]

TAXONOMY, BIOLOGY, DAMAGE

135 Flory, C.H.; Nettles, W.C.; Barker, W.J.
1955. **Forest insects and diseases of South Carolina trees.** S. Car. Agric. Ext. Bull. 116. 15 p.
Brief accounts of the nature of injury, habits, and chemical control of *Dendroctonus terebrans* and the three *Ips* species.
LIFE HISTORY, DAMAGE, PREVENTION, CHEMICAL CONTROL

136 Franklin, R.T.
1969. **Hymenopterous parasites of the southern pine beetle in Georgia.** J. Ga. Entomol. Soc. 4:119-122. 1 tab, 10 refs.
Presents brief biological data on fifteen species of Hymenoptera associated with *Dendroctonus frontalis*; six species were proven to be parasites. Includes a report that *Roptrocerus eccoptogastri* also attacks *Ips avulsus* and *I. grandicollis*.
PARASITES, PARASITE BIOLOGY, ASSOCIATES

137 Friend, R.B.
1940. **Connecticut state entomologist, thirty-ninth report, 1939.** Conn. Agric. Exp. Stn. Bull. No. 434, Pages 222-322, 7 figs.
See Plumb and Decaprio 1940.
OUTBREAK

138 Friend, R.B.
1942. **Enemies of loblolly pine. Insects.** Pages 143-145 in H. H. Chapman. Management of loblolly pine in the pine-hardwood region in Arkansas and in Louisiana west of the Mississippi River. Yale Univ. Sch. For. Bull. 49.
Briefly mentions *Dendroctonus terebrans* and *Ips* species in a short discussion of the major insect problems of loblolly pine.
DAMAGE

139 Frost, S.W
1964. **Insects taken in light traps at the Archbold Biological Station, Highlands County, Florida.** Fla. Entomol. 47:129-161. 4 refs.
Lists dates of collection and realtive abundance of more than 1000 species of insects collected in light traps in Highlands County, Florida. *Ips grandicollis* was caught on one date in November and *Dendroctonus terebrans* on two days in March-April.
LIGHT TRAPS

140 Furniss, R.L.; Carolin, V.M.
1977. **Western forest insects.** U. S. For. Serv. Misc. Publ. No. 1339, 654 p.
Pages 383-398 of this textbook provide brief descriptions of the biology, hosts, distributions, and importance of 25 *Ips* species occurring in western North America. *Ips calligraphus* is included because of its transcontinental distribution.
BIOLOGY, DISTRIBUTION, DAMAGE, HOST TREES

141 Germar, E.F.
1824. **Insectorum species novae aut minus cognitae, descriptionibus illustratae.** Halle: J. C. Hendel & Son. 624 p. (Written in Latin.).
The original taxonomic description for *Ips calligraphus* (pp. 461-462). Germar described the species as *Tomicus calligraphus* [ not *Bostrichus calligraphus* as cited by some authors] and the type locality is Kentucky.
TAXONOMY

142 Godbee, J.F.
1974. **Bionomics of the black turpentine beetle, *Dendroctonus terebrans* (Olivier).** Athens, Ga.: Univ. of Ga. iii + 65 p. 10 tabs, 7 figs, 27 refs. M. Sci. Thesis.
See Godbee and Franklin 1976, 1978.
REARING, SEX RATIO, SEX DETERMINATION, AGGREGATION PHEROMONES, ATTRACTANTS, BEHAVIOR, ATTACK, STRIDULATION

143 Godbee, J.F.; Franklin, R.T.
1976. **Attraction, attack patterns and seasonal activity of the black turpentine beetle.** Ann. Entomol. Soc. Am. 69:653-655. 1 tab, 2 figs, 7 refs.
The height distribution of *Dendroctonus terebrans* attacks on loblolly pine in northern Georgia was similar to Smith's (1957) data for slash and longleaf pines in northern Florida. The duration of attacks on individual trees was about 2.5 months whereas Smith (1957) reported a 5 to 7 month attack period. Bolts artificially infested with males or females attracted significantly more beetles than did bolts infested with both sexes. The authors suggest that the females are the host-finding and gallery-initiating sex.
REARING, AGGREGATION PHEROMONES, ATTRACTANTS, BEHAVIOR, ATTACK, LIGHT, FLIGHT TRAPS, BOLT TRAPS

144 Godbee, J.F.; Franklin, R.T.
1978. **Sexing and rearing the black turpentine beetle (Coleptera: Scolytidae).** Can. Entomol. 110:1087-1089. 1 fig, 10 refs.
Beetles were successfully reared on pine bolts with peak brood emergence occurring at 78 and 65 days for rearing temperatures of 23 and 28 deg. C, respectively. The sex ratio was 1:1. The shape of the seventh abdominal tergite was the best character for sexing adults although experienced personnel could usually distinguish the high-pitched chirping of the males from the rasping sound produced by females.
REARING, SEX RATIO, STRIDULATION, SEX DETERMINATION

145 Gold, H.J.; Mawby, W.D.; Hain, F.P.
1980. **A framework for modeling endemic-epidemic transitions in southern pine beetle.** Pages 27-32 in Hain, F.P., ed. Proc. Work Conf. on Population Dynamics of Forest Insects at Low Levels, N.C. State Univ., Raleigh, N.C. (August 1979). 3 figs, 1 tab, 20 refs.
The distribution, abundance, and suitability of *Ips*-infested trees are important components of this model for endemic *Dendroctonus frontalis* populations.
POPULATION DYNAMICS, MODELING

146 Goldman, S.E.; Parker, J.A.
1978a. **Development of immature stages of black turpentine and *Ips* beetles in paraquat-treated slash pine.** South. J. Appl. For. 2:22-24. 9 refs.
*Ips* spp. and, to a lesser degree, *Dendroctonus terebrans* established broods in slash pines treated with 1% and 3% paraquat. The low incidence of attacks on untreated trees precluded a comparison of attack success, oviposition, and brood mortality rates.
GROWTH, LIGHTWOOD INDUCTION, PARAQUAT

147 Goldman, S.E.; Parker, J.A.
1978b. **Beetle reponse to, and development in, paraquat treated slash pine.** Pages 88-89 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.
A nontechnical synopsis of Goldman and Parker 1978a and Goldman et al. 1978, 1979.
MATING, OVIPOSITION, ATTACK, LIGHTWOOD INDUCTION, PARAQUAT

148 Goldman, S.E.; Cleveland, G.D.; Parker, J.A.
1978. **Beetle response to slash pines treated with paraquat to induce lightwood formation.** Environ. Entomol. 7:372-374. 1 tab, 12 refs.
Paraquat concentration (0, 1, and 3%) and application method did not significantly affect numbers of *Ips* spp. and *Dendroctonus terebrans* captured in window-pane traps at the bases of treated slash pines. The authors suggest that beetles initially respond to the treatment wounds and that later response is associated with paraquat-induced physiological changes in the tree.
ATTRACTANTS, TREE PHYSIOLOGY, LIGHTWOOD INDUCTION, PARAQUAT, TRAPS

149 Goldman, S.E.; Cleveland, G.D.; Parker, J.A.
1979. **Lightwood induction and associated beetle attacks on slash pine.** For. Sci. 25:80-83. 3 tabs, 12 refs.
Analysis of bark beetle attack and tree mortality data 19 to 21 months after winter applications showed no significant differences associated with method of paraquat application. *Dendroctonus terebrans* and *Ips* spp. attacks and tree mortality both increased with increasing paraquat concentration (0, 1, and 3%) and with proportion of the circumference treated (1/4 versus 1/3). Nearly all the dead trees showed signs of bark beetle attacks. All trees showing signs of *Ips* attacks, with or without *D. terebrans* attacks, died; the mortality rate was 32% for trees showing only *D. terebrans* attacks.
LIGHTWOOD INDUCTION, PARAQUAT

150 Gouger, R.J.
1971. **Interrelations of *Ips avulsus* (Eichh.) and associated fungi.** Gainesville, FL: Univ. of Florida. Available from: University Microfilms, Ann Arbor, MI. Order no. 72-15,682. xi + 95 p. Dissertation.
See Gouger et al. 1975 and Yearian et al. 1972.
FUNGI, YEASTS, NUTRITION

151 Gouger, R.J.; Yearian, W.C.; Wilkinson, R.C.
1975. **Feeding and reproductive behavior of *Ips avulsus*.** Fla. Entomol. 58:221-229. 3 figs, 17 refs.
*Ips avulsus* adults ingest chips of phloem tissue, compress it with their mandibles, then expell the residual pellet and push it to the rear. The gut contains principally microorganisms, starch grains, and very fine host material. Both sexes produce gelatinous feces. *Ips calligraphus* is also a liquid feeder and producer of gelatinous feces. Mating of *I. avulsus* occurs after the female has constructed ca. 3 mm of egg gallery. Copulation lasts 22-45 sec and typically occurs 3 times at about 10-minute intervals. After constructing each lateral egg niche, the female reverses her position in the gallery, quickly deposits a single egg, then returns to her original position and packs a phloem plug around the egg.
MORPHOLOGY, BEHAVIOR, MATING, FEEDING

152 Goyer, R.A.; Lenhard, G.J.; Nebeker, T.E.; Jarrard, L.D.
1980. **How to identify common insect associates of the southern pine beetle.** U. S. Dep. Agric. Agric. Handb. 563. 33 p. 66 figs, 6 refs.
*Dendroctonus terebrans*, the 3 *Ips* species, and many of their insect associates are illustrated by excellent color photographs.
PARASITES, PREDATORS, IDENTIFICATION

153 Grissell, E.E.
1979. **Catalog of Hymenoptera in America North of Mexico. Family Torymidae.** Pages 748-768 in Karl V. Krombein et al., Catalog of Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, DC. 2735 pages in 3 volumes.
*Roptrocerus xylophagorum* (Ratzeburg) is listed as a confirmed parasite of *Ips calligraphus* and *I. grandicollis*.
PARASITES

154 Hagedorn, M.
1910. **Ipidae.** Berlin: W. Junk. Coleopterorum Catalogus 4:1-134.
Lists major taxonomic and biological literature and the geographic distribution for *Dendroctonus terebrans* (p. 23) with 23 other *Dendroctonus* species. Similar information is given for 72 *Ips* species, including *I. avulsus* (pp. 48-49), *I. calligraphus* (pp. 50-51), and *I. grandicollis* (p. 54).
TAXONOMY

155 Hain, F.P.
1969. **Response and attack behavior of *Ips grandicollis* (Coleoptera, Scolytidae).** Durham, NC: Duke Univ. School of Forestry. vii + 93 p. 22 tabs, 25 figs. Thesis.
See Hain and Anderson 1976a, 1976b, and Hertel et al. 1969.
REEMERGENCE, EMERGENCE, PHOTOTAXIS, CHEMOTAXIS, PHEROMONE PRODUCTION, ATTRACTANTS, DISPERSAL, ATTACK

156 Hain, F.P.; Anderson, R.F.
1976a. **Effect of age, flight exercise and feeding on the field attractant response of *Ips grandicollis*.** J. Ga. Entomol. Soc. 11:30-34. 1 tab, 1 fig, 6 refs.
Reports on field tests evaluating how adult *Ips grandicollis*, preconditioned in several ways, responded to male-infested pine bolts.
PHEROMONES, AGGREGATION PHEROMONES, BEHAVIOR, FLIGHT

157 Hain, F.P.; Anderson, R.F.
1976b. **Some response and attack behaviors of *Ips grandicollis*.** J. Ga. Entomol. Soc. 11:157-162. 2 figs, 14 refs.
Reports the responses of field-collected and laboratory-reared *Ips grandicollis* to uninfested and male-infested loblolly pine bolts. The authors suggest that recently emerged adults have a strong instinct to disperse before initiating attacks.
PHEROMONES, ATTRACTANTS, ATTACK, FLIGHT, BEHAVIOR

158 Hain, F.P.; McClelland, W.T.
1980. **Studies of declining and low level populations of the southern pine beetle in North Carolina.** Pages 9-26 in Hain, F.P., ed. Proc. Work Conf. on Population Dynamics of Forest Insects at Low Levels, N.C. State Univ., Raleigh, N.C. (August 1979). 16 figs, 12 tabs, 17 refs.
Data collected over a four year period indicate that *Dendroctonus frontalis*, in its endemic phase, frequently infested trees first colonized by *Ips* beetles. *Dendroctonus terebrans* was present in 8% of the trees in expanding *Dendroctonus frontalis* infestations, but was absent in all non-expanding infestations.
POPULATION DYNAMICS, STAND CONDITIONS, SITE FACTORS, SOIL NUTRIENTS

159 Haliburton, W.
1943. **Some factors in the environmental resistance of *Ips* DeGeer.** Durham, NC: Duke Univ. Sch. of Forestry. vi + 59 p. 28 figs, 28 refs. Thesis.
Over 100 species of insects and other arthropods were collected or reared from pine bolts naturally infested by the three common *Ips* species. The habits and biotic potentials of the *Ips* beetles are discussed briefly. Other topics treated are host resistance, physical environmental factors, nutrition, interspecific competition among larvae, and limiting biotic factors such as parasites, predators, and fungi. Also mentions (p. 49) the occasional occurrence of *Dendroctonus terebrans* in the Duke Forest.

PHYSICAL FACTORS, MITES, FUNGI, YEASTS, NEMATODES, SEX RATIO, FECUNDITY, PARASITES, PREDATORS, COMPETITION, ASSOCIATES, HOST RESISTANCE

160 Hamilton, J.
1895. **Catalogue of the Coleoptera of southwestern Pennsylvania, with notes and descriptions.** Trans. Am. Entomol. Soc. 22:317-381.
Lists (p. 346) 27 species of Scolytidae occurring in southwestern Pennsylvania and provides brief notes on host plants and abundance for 16 species (p. 378). Included are *Tomicus cacographus* LeConte [ = *Ips grandicollis*] and *Dendroctonus terebrans*. [Hopkins (1909, p. 157) stated that information for the latter species is for *D. valens* LeConte.]
GEOGRAPHIC DISTRIBUTION, HOST TREES

161 Harris, T.W.
1841. **A report on the insects of Massachusetts injurious to vegetation.** Cambridge: Folsom, Wells, and Thurston. Pages 71-73.
Harris, in this and all other editions of his popular book, obviously describes characters and habits of the red turpentine beetle, *Dendroctonus valens* LeConte, even though he calls it *Scolytus terebrans* or *Hylurgus terebrans* of Olivier. The morphology and habits of *Ips calligraphus* are discussed briefly under the name *Tomicus exesus* (Say).
TAXONOMY, MORPHOLOGY, BEHAVIOR, DAMAGE, HOST TREES

162 Harris, T.W.
1862. **A treatise on some of the insects injurious to vegetation.** Boston: Printer of the State of Massachusetts. 3rd. edition, pp.85-87.
See Harris 1841.
BEHAVIOR, DAMAGE, HOST TREES

163 Harrison, R.P.
1956. **Bark beetles and their control in Georgia.** Ga. For. Res. Council Rep. No. 2, 10 p.
A brief, illustrated report describing the identification of the bark beetles attacking southern pines and how to prevent and control bark beetle infestations.
LIFE HISTORY, CHEMICAL CONTROL, CULTURAL CONTROL, BHC

164 Hedden, R.L.; Vité, J.P.; Mori, K.
1976. **Synergistic effect of a pheromone and a kairomone on host selection and colonisation by *Ips avulsus*.** Nature 261:696-697. 1 tab, 13 refs.
Combinations of the *Ips avulsus* pheromone ipsdienol and the *I. grandicollis* pheromone ipsenol attracted more *I. avulsus* than either single pheromone. Also, the s-(-)-isomer was identified as the active isomer of ipsenol. The authors suggest that this synergism favors successful host colonization and their results do not support two hypotheses on the role of pheromones in maintaining species integrity and reducing interspecific competition in sympatric species of *Ips*.
PHEROMONES, KAIROMONES, IPSDIENOL, IPSENOL

165 Heikkenen, H.J.
1977. **Southern pine beetle: A hypothesis regarding its primary attractant.** J. For. 75: 408,413. 1 fig, 2 tabs, 18 refs.
Loblolly pines severed and guyed upright were mass attacked by *Dendroctonus frontalis* 3 to 7 weeks following treatment. Midbole flight trap catches of *D. terebrans, Ips avulsus, I. grandicollis*, and *I. calligraphus* were 1 to 4 % of the *D. frontalis* total. Few bark beetles were caught on untreated trees and girdled trees. The author hypothesizes that intial *D. frontalis* attack occurs in response to volatiles emitted by dead pines.
HOST FINDING, BEHAVIOR, TREE CONDITIONS

166 Heller, R.C.; Aldrich, R.C.; Bailey, W.F.; Merkel, E.P.
1955. **Status of *Ips* pine engraver beetle epidemic in southern Georgia — an aerial detection and damage appraisal survey.** For. Insect Survey Rep. No. 7 [Unpublished], U. S. For. Serv., Southeast. For. Exp. Stn., Asheville, N.C. 7 p. 5 tabs, 1 fig.
Presents the results of an October aerial survey of 37 counties to determine the extent and severity of the 1955 *Ips* and black turpentine beetle outbreak. The estimated volume loss of 44,531 cords was 57% less than the estimated loss for the same area in 1954 (see Merkel et al. 1955).
OUTBREAK, DAMAGE, SURVEYS

167 Hertel, G.D.
1968. **Factors influencing the attraction, movement and concentration of *Ips grandicollis* (Eichh.).** Durham, NC: Duke Univ. Sch. of Forestry. viii + 107 p. 18 tabs, 20 figs, 85 refs. Thesis.
See Hertel et al. 1969.
PHYSICAL FACTORS, LIGHT, TEMPERATURE, WIND, RELATIVE HUMIDITY, SEX RATIO, MARK-RELEASE-RECAPTURE, AGGREGATION PHEROMONES, ATTRACTANTS, FLIGHT, DISPERSAL

168 Hertel, G.D.; Hain, F.P.; Anderson, R.F.
1969. **Response of *Ips grandicollis* (Coleoptera: Scolytidae) to the attractant produced by attacking male beetles.** Can. Entomol. 101:1084-1091. 4 figs, 4 tabs, 25 refs.
Logs artificially infested with males attracted more *Ips grandicollis* than no-log and uninfested-log controls. Attractiveness was related to the total number of introduced males. Most flight occurred during the evening twilight period. Responding beetles were 56% females, about the same as emerged in laboratory reared populations. In an open field release experiment, 75% flew within 15 minutes, 90% within one hour. Most released beetles flew down wind, only 15% upwind and 25% perpendicular to the wind. A mark-release study recaptured a higher proportion (8.4%) of previously captured older adults than of the newly emerged adults (2.1%). Attack densities on unscreened logs were lowest in the logging area producing the new brood, greatest at 100 meters, and decreased thereafter with increasing distance.
BIOLOGY. SEX RATIO. ADULT BIOLOGY. DISPERSAL, ECOLOGY. PHEROMONE PRODUCTION. AGGREGATION PHEROMONES, BEHAVIOR. ATTACK, FLIGHT

169 Hertel, G.D.; Williams, I.L.
1975. **Impact and control of insects on slash pines treated with paraquat to induce lightwood formation - a progress report.** Pages 51-57 in R. H. Stone, ed. Proc. Annu. Meet. Lightwood Res. Coord. Council. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 120 p.
Preliminary (5 month) results of tests in north Florida demonstrated that aqueous emulsions containing 1% BHC and 1% and 2% chlorpyrifos (dursban) were effective in preventing attacks by *Ips* spp., black turpentine beetle, and ambrosia beetles when applied to the basal 1 m of paraquat-treated slash pines. Result of these studies 16 to 18 months after paraquat application are given in Hertel, Williams, and Merkel (1977). One study is reported which emphasizes the importance of spraying trees with BHC immediately following paraquat treatment rather than spraying prior to or waiting 1-3 weeks after paraquat application.
CHEMICAL CONTROL. TREE MORTALITY, LIGHTWOOD INDUCTION. PARAQUAT

170 Hertel, G.D.; Williams, I.L.; Merkel, E.P.
1977. **Insect attacks on and mortality of slash and longleaf pines treated with paraquat to induce lightwood formation.** U. S. For. Serv. Res. Pap. SE-169. 13 p. 5 tabs, 1 fig, 11 refs.
In a study of paraquat treatments aplied in early June, *Dendroctonus terebrans* attacked treated trees within a few weeks, *Platypus flavicornis* arrived next, and *Ips* species came somewhat later. No brood was observed emerging from any of the 20 dead paraquat-treated trees. Treatments in other months showed that tree mortality was lowest for paraquat treatments applied in November, and increased in order for January, July, and April. Tree mortality decreased with decreasing wound size and paraquat concentration. Application of lindane and BHC to the basal 1 m reduced insect-caused tree mortality.
PHYSIOLOGY, DEVELOPMENT, ATTRACTANTS, DAMAGE, CHEMICAL CONTROL, PARAQUAT, LIGHTWOOD INDUCTION, LINDANE, BHC

171 Hetrick, L.A.
1942. **Some observations of *Ips* bark beetle attack on pine trees.** J. Econ. Entomol. 35:181-183. 2 figs, 6 refs.
Observations over a three year period indicated that trunk and crown injuries, root injuries, and close proximity to harvesting operations were major factors responsible for *Ips* species attacking and killing pines in eastern Virginia. *I. calligraphus* was frequently the first to attack thick-barked *Pinus taeda*, whereas *I. avulsus* was responsible for primary attacks on smaller, thin-barked *P. virginiana*. *I. grandicollis* and *Orthotomicus caelatus* were generally secondary pests.
HOST TREES, DAMAGE, LIGHTNING, FIRE

172 Hetrick, L.A.; Moses, P.J.
1953. **Value of insecticides for protection of pine pulpwood.** J. Econ. Entomol. 46:160. 1 tab.
BHC was superior to 7 other chlorinated hydrocarbon insecticides for protecting stacked pulpwood from bark beetles and wood borers.
CHEMICAL CONTROL, ALDRIN, BHC, CHLORDANE, DIELDRIN, ENDRIN, HEPTACHLOR, ISODRIN, TOXAPHENE

173 Hetrick, L.A.
1957. **Two promising new chemicals for control of insects attacking freshly-cut pine wood.** Station to Station Res. News 3(4):1-2. Union Carbide Chemicals Co., White Plains, NY.
Sevin applied to freshly cut pine logs in June delayed infestations by bark beetles and sawyers for about 6 weeks. Delnav was effective for about 3 weeks. At 9 weeks, black turpentine beetle broods were discovered in portions of treated logs in contact with the soil.
CHEMICAL CONTROL, SEVIN, DELNAV

174 Hetrick, L.A.
1960. **Factors that contribute to pine bark beetle attack.** Forest Farmer 19(6):12,16; June 1960.
Root injury, due to a variety of causes, is considered by the author to be a major factor responsible for bark beetle attacks on southern pines.
HOST TREES, STRESS

175 Hill, T.M.; Fox, R.C.
1972. **Two pine seedling weevils attracted to pines infested by the black turpentine beetle.** Ann. Entomol. Soc. Am. 65:269. 2 refs.
Based on pine disc-trap catches, the authors conclude that *Hylobius pales* and *Pachylobius picivorus* were attracted to a loblolly pine infested by *Dendroctonus terebrans*.
BEHAVIOR, HOST FINDING, TRAPPING

176 Himes, W.E.; Skelly, J.M.
1972. **An association of the black turpentine beetle, *Dendroctonus terebrans*, and *Fomes annosus* in loblolly pine.** Phytopathology 62:670.
*Fomes annosus* was isolated from 11% of the larvae, pupae, and adults of *Dendroctonus terebrans* removed from infected loblolly pines. The authors conclude that *D. terebrans* likely functions as a vector of *F. annosus*.
FUNGI, PATHOLOGY, PLANT DISEASE VECTORS

177 Hinckley, A.D.
1969. **Radiation-induced fluctuations in forest insect populations.** Abstr. Radiat. Res. 39:502.
Summarizes several studies of gamma-radiation effects on insect populations. See Brower (1974, 1977) for the original information regarding *Ips grandicollis* and *I. calligraphus*.
ECOLOGY, POPULATION DYNAMICS, GAMMA RADIATION

178 Hines, J.W.; Heikkenen, H.J.
1977. **Beetles attracted to severed Virginia pine (*Pinus virginiana* Mill.).** Environ. Entomol. 6:123-127. 2 figs, 6 tabs, 6 refs.
Thirty species of beetles were collected in flight traps placed at the midbole of standing pines which had been cabled and severed. *Pityogenes plagiatus* was the most abundant of the species collected, *Ips avulsus* was second, *I. grandicollis* was third. Greatest numbers of these 3 species were collected before the foliage turned from green to yellow and very few were caught when the foliage was red. The *Ips* spp. were generally present from April to September and most abundant in June, July, and August.
ATTRACTION, HOST FINDING, STRESS

179 Hochmut, R.; Milan Manso, D.
1975. **Proteccion contra las plagas forestales en Cuba.** Instituto Cubano del Libro, Havana. 290 p.
This is a Spanish language forest entomology textbook. Included are descriptions, bionomic notes, damage, and control methods for *Ips interstitialis* (p. 206) and *I. grandicollis* (p. 210) in Cuba.
BIOLOGY, DAMAGE, APPLIED CONTROL

180 Hodges, J.D.; Pickard, L.S.
1971. **Lightning in the ecology of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae).** Can. Entomol. 103:44-51. 3 tabs, 1 fig, 20 refs.
Physical and chemical changes in lightning-struck loblolly pines are discussed in relation to the attack and development of *Dendroctonus frontalis*, *D. terebrans*, and the 3 *Ips* species.
LIGHTNING, DISTRIBUTION, COMPETITION, ECOLOGY, BROOD DEVELOPMENT, BROOD MATERIAL, TREE PHYSIOLOGY, RELATIVE WATER CONTENT, OLEORESIN PRODUCTION, SUCROSE, REDUCING SUGARS, CARBOHYDRATES, AMINO NITROGEN

181 Hoffard, W.H.; Coster, J.E.
1976. **Endoparasitic nematodes of *Ips* bark beetles in eastern Texas.** Environ. Entomol. 5:128-132. 1 tab, 3 figs, 16 refs.
Four species of nematodes were found infesting *Ips* beetles. Infection levels of emerging beetles were greatest in the summer months (ca. 50%) and least in the winter (ca. 20%). There were no obvious anatomical changes due to nematode infection. Limited data showed no significant changes in egg gallery length or number of larval mines resulting from infection of parent beetles. The authors point out the need for detailed, long-term studies to determine the effects of each parasite on the population dynamics of its host beetle.
NEMATODES, FECUNDITY, DEVELOPMENT, METABOLISM

182 Holst, E.C.

1937. **Aseptic rearing of bark beetles.** J. Econ. Entomol. 30:676-677. 2 refs.

Eggs removed from naturally infested trees were surface sterilized in 95% ethanol and then incubated. Newly hatched larvae were place into previously autoclaved phloem squares taped between glass. Two of 6 larvae of *Ips calligraphus* and 10 of 71 *I. grandicollis* larvae were reared to maturity. Most of the failures were attributed to drying of the phloem.

REARING

183 Holt, W.R.

1961. ***Metarrhizium anisopliae* (Metchnikoff) Sorokin infecting larvae of the black turpentine beetle.** J. Insect Pathol. 3:93.

The green muscadine fungus infected mature larvae of *Dendroctonus terebrans* in pupal cells in loblolly pine stumps in southern Mississippi. Pupae in the same stump apparently were not infected by the fungus and were reared to adults in gelatin capsules. Larvae in trees and stumps nearby were healthy. This was believed to be a new host record for this fungus.

PATHOLOGY, BIOLOGICAL CONTROL, FUNGI

184 Hopkins, A.D.

1892. **Notes on a destructive forest tree scolytid.** Science 20:64-65; 29 July 1892.

In this brief account of the 1891-1892 *Dendroctonus frontalis* outbreak in West Virginia, Hopkins states that *Tomicus* [ = *Ips*] *calligraphus* often infested the green bark on the stem above the *D. frontalis* infestation. He also states that *D. terebrans* [later corrected to *D. valens* (Hopkins 1909a, p. 157)] and *Hylurgops glabratus* [ = *H. rugipennis pinifex*] attacked the bases of infested trees.

OUTBREAK, BIOLOGY

185 Hopkins, A.D.

1893a. **Catalogue of West Virginia Scolytidae and their enemies.** W. Va. Agric. Exp. Stn. Bull. 31:121-168.

Lists 80 species of Scolytidae and their parasites, predators, and associates reared from forest and shade trees in West Virginia. Each insect species is annotated with the host tree or insect, nature of damage, and when and where collected. Includes insect and host tree indices. Included in the list are *Tomicus* [ = *Ips*] *calligraphus* (p. 138), *T. cacographus* [ =*I. grandicollis*] (p. 138), *T. avulsus* (p. 139), and *Dendroctonus terebrans* (p. 143) [Hampshire and Monongalia counties only; the collections from other areas are *D. valens* LeConte (Hopkins 1909a, p. 157)].

PARASITES, PREDATORS, ASSOCIATES, DAMAGE, HOST TREES

186 Hopkins, A.D.

1893b. **Catalogue of West Virginia forest and shade tree insects.** W. Va. Agric. Exp. Stn. Bull. 32:171-251.

Lists nearly 500 species of insects collected or reared from trees in West Virginia and gives information on where and when they were collected. For the bark beetles, however, only the host tree data are provided because the other information was already included in the companion bulletin no. 31 (see Hopkins 1893a).

PARASITES, PREDATORS, ASSOCIATES, HOST TREES

187 Hopkins, A.D.

1894. **Sexual characters in Scolytidae.** Can. Entomol. 26(10):274-280.

Adult external characters of possible use in distinguishing between males and females are briefly discussed for *Tomicus* [ = *Ips*] *calligraphus* and *T. cacographus* [ = *I. grandicollis*] on p. 279 and for *Dendroctonus terebrans* on p. 280.

SEXUAL CHARACTERS

188 Hopkins, A.D.

1897. **Report of entomologist.** W. Va. Agric. Exp. Stn. 6th Annu. Rep. for the fiscal year ending June 30, 1893. pp. 29-42.

Hopkins (1909a, p. 157) states that the *Dendroctonus terebrans* outbreak reported on page 41 of this report really pertains to *D. valens*.

BIOLOGY, OUTBREAK, PREDATORS

189 Hopkins, A.D.

1899a. **Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893.** W. Va. Agric. Exp. Stn. Bull. 56:197-461.

Hopkins gives a description of the adult (pp. 392-394), habits, life history, host trees, characters of injury, and natural enemies (pp. 415-421) for *Dendroctonus terebrans*, but in his 1909 monograph he states that the species is really *D. valens* LeConte. Adults of *Tomicus* [ = *Ips*] *calligraphus*, *T. cacographus* [ = *I. grandicollis*] and *T. avulsus* are described on pp. 422-423.

LIFE HISTORY, BEHAVIOR, DAMAGE, BIOLOGICAL CONTROL, PHYSICAL CONTROL, HOST TREES, LIFE STAGES

190 Hopkins, A.D.

1899b. **Preliminary report on the insect enemies of forests in the Northwest.** U. S. Dep. Agric. Div. Entomol. Bull. 21 (new series). 27 p.

Hopkins refers to *D. terebrans* in this report of insects from the West, but it is apparent that he was dealing with *D. valens* for he was careful to collect "western representatives of *D. terebrans*" in order "to arrive at definite conclusions regarding the identity of numerous doubtful forms collected."

DAMAGE, HOST TREES

191 Hopkins, A.D.

1899c. **[Notes on Scolytidae, with especial reference to habits]** Proc. Entomol. Soc. Wash. 4(3):343.

Describes how *Dendroctonus valens* [misidentified as *D. terebrans*] produces a stridulating sound by rubbing the dorsal margin of the last abdominal segment against the inner surface of the elytra near the tips.

MORPHOLOGY, STRIDULATION

192 Hopkins, A.D.

1901. **Insect enemies of the spruce in the Northeast.** U. S. Dep. Agric. Div. Entomol. Bull. 28 (new series). 81 p. 16 plates.

The original taxonomic description for *Dendroctonus piceaperda* [ =*D. rufipennis* Kirby, 1837] and a detailed description of its biology. Plate XII (pp. 72-73) repeats several of Hopkins' (1899a) illustrations on the workings of *D. valens* misidentified as *D. terebrans*.

TAXONOMY, BIOLOGY, MORPHOLOGY, GALLERY PATTERN

193 Hopkins, A.D.

1902. **Insect enemies of the pine in the Black Hills Forest Preserve.** U. S. Dep. Agric. Div. Entomol. Bull. 32 (new series). 24 p. 7 plates.

Describes the new species *Dendroctonus ponderosae*, provides information on its biology and damage, and makes recommendations for preventing losses. In a footnote on page 10 Hopkins states, "This species has heretofore been erroneously identified as *D. terebrans* and *D. rufipennis*, and will probably be found so labeled in some collections." Among the secondary insects discussed and illustrated are *Tomicus oregoni* [ =*Ips pini*], *Tomicus calligraphus* Germ. var. *occidentalis* [ = *I. calligraphus ponderosae*], and *Dendroctonus valens*.

TAXONOMY, BIOLOGY, PARASITES, PREDATORS, OUTBREAK

194 Hopkins, A.D.
1904. **Catalogue of exhibits of insect enemies of forests and forest products at the Louisiana Purchase Exposition, St. Louis, Mo., 1904.** U. S. Dep. Agric. Div. Entomol. Bull. 48 (new series). 56 p. + 22 plates.
This bulletin was prepared to supplement a 54 case exhibit of destructive forest insects. *Tomicus* [=*Ips*] *avulsus* is displayed in two cases and described as the "companion bark beetle" because it frequently accompanies *Dendroctonus frontalis* as a secondary enemy. Plate 7, showing the work of *D. frontalis* and *D. valens*, is a repeat of Plate 12 from Bulletin 28 (Hopkins 1901) with most of the legend changed to read *D. valens* rather than the previously stated *D. terebrans*.
ADULTS, GALLERIES

195 Hopkins, A.D.
1905a. **Notes on some Mexican Scolytidae, with descriptions of some new species.** Proc. Entomol. Soc. Wash. 7:71-81. [Preprint dated 9 December 1905. Journal published 10 January 1906.]
In his discussion following the identification of *Dendroctonus valens* from Mexico, Hopkins for the first time clearly distinguishes between *D. valens* and *D. terebrans* and points out that the latter name is for the black form found only in the eastern and southern United States.
TAXONOMY, MORPHOLOGY, DISTRIBUTION

196 Hopkins, A.D.
1905b. **Notes on Scolytid larvae and their mouth parts.** Proc. Entomol. Soc. Wash. 7:143-149. 9 figs. Preprint dated 9 December 1905. Journal published 10 January 1906. .
Discusses larval characters, particularly of the labrum and clypeus, which are useful for classifying the species of *Dendroctonus* into natural divisions and series. The front, labrum, and clypeus of *D. terebrans* are illustrated.
MORPHOLOGY, LARVAE

197 Hopkins, A.D.
1909a. **Contributions toward a monograph of the scolytid beetles. I. The genus *Dendroctonus*.** U. S. Dep. Agric. Bur. Entomol. Tech. Series 17 (part 1):1-164. 95 figs, 8 plates.
An excellent treatise on the anatomy of mature and immature stages of *Dendroctonus* beetles and a taxonomic revision of the genus. Describes the larval, pupal and adult stages, host trees, and distribution of *D. terebrans* on pages 147-150. The annotated bibliographies and revisional notes for *D. valens* and *D. terebrans* are the best sources of information for correcting the earlier literature when these two species were confounded under the latter name.
TAXONOMY, MORPHOLOGY, BIOLOGY, DISTRIBUTION, HOST TREES, BIBLIOGRAPHY

198 Hopkins, A.D.
1909b. **Practical information on the scolytid beetles of North American forests. I. Bark beetles of the genus *Dendroctonus*.** U. S. Dep. Agric. Bur. Entomol. Bull. 83 (part 1):1-169.
This bulletin is a companion to Hopkins' (1909a) taxonomic monograph and provides information of practical interest and importance on 23 species of *Dendroctonus*. The seasonal history, habits, damage, and methods of control for *D. terebrans* are described on pages 146-153.
LIFE HISTORY, BEHAVIOR, DAMAGE, APPLIED CONTROL

199 Hopkins, A.D.
1909c. **Some insects injurious to forests. V. Insect depredations in North American forests and practical methods of prevention and control.** U. S. Dep. Agric. Bur. Entomol. Bull. 58:57-101.
Briefly describes (pp. 61-62) the combined damage of southern pines by *Dendroctonus terebrans*, *Buprestis apricans*, and fire.
ASSOCIATES, DAMAGE

200 Hopkins, A.D.
1915. **Contributions toward a monograph of the scolytid beetles. II. Preliminary classification of the superfamily Scolytoidea.** U. S. Dep. Agric. Tech. Series 17 (part 2):165-247. Figs 96-112, plates IX-XVI.
Contains an extensive description of morphological and physiological characters of scolytid beetles considered by Hopkins to be useful in their taxonomy. Classifies the Scolytoidea into the four families Ipidae, Scolytidae, Scolytoplatidae, and Platypodidae with 10, 6, 1, and 3 subfamilies, respectively. *Dendroctonus terebrans* and *D. valens* are mentioned as one of several examples of "paired or parallel species" (p. 211).
TAXONOMY, MORPHOLOGY

201 Hopping, G.R.
1963. **Generic characters in the tribe Ipini (Coleoptera: Scolytidae), with a new species, a new combination, and new synonymy.** Can. Entomol. 95:61-68. 36 figs, 6 refs.
Presents a key using characters of the antennae, elytral declivity, and male genitalia to distinguish *Ips*, *Pityokteines*, *Orthotomicus*, and *Orthotomides*. Figure 28 illustrates the male genitalia of *Ips grandicollis*.
TAXONOMY, MORPHOLOGY

202 Hopping, G.R.
1963. **The natural groups of species in the genus *Ips* DeGeer (Coleoptera: Scolytidae) in North America.** Can. Entomol. 95:508-516. 45 figs, 10 refs.
The 32 recognized species of North American *Ips* are organized into 10 groups of closely related species. *Ips avulsus*, *I. grandicollis*, and *I. calligraphus* are placed in groups IV, IX, and X, respectively.
TAXONOMY, MORPHOLOGY

203 Hopping, G.R.
1964. **The North American species in the groups IV and V of *Ips* DeGeer (Coleoptera: Scolytidae).** Can. Entomol. 96:970-978. 15 figs, 6 refs.
Summarizes the taxonomic history, morphological characters, geographic distribution, and gallery patterns for *Ips avulsus* and other species in Hopping's groups IV and V.
MORPHOLOGY, TAXONOMY, DISTRIBUTION, HOST TREES

204 Hopping, G.R.
1965a. **North American species in group IX of *Ips* DeGeer (Coleoptera: Scolytidae).** Can. Entomol. 97:422-434. 16 figs, 15 refs.
Includes a description of *Ips grandicollis* adults plus information on the geographic distribution and known hosts of this species. *I. chagnoni* Swaine (1916) is made a synonym of *I. grandicollis*.
TAXONOMY, MORPHOLOGY, DISTRIBUTION, HOST TREES

205 Hopping, G.R.
1965b. **The North American species in group X of *Ips* DeGeer (Coleoptera: Scolytidae).** Can. Entomol. 97:803-809. 1 tab, 7 figs, 16 refs.
Describes the morphology, geographic distribution, and known hosts of *Ips calligraphus*, and proposes *I. ponderosae* Swaine and *I. interstitialis* (Eichhoff) as synonyms of *I. calligraphus*. [Cf. Lanier 1972]
TAXONOMY, MORPHOLOGY, DISTRIBUTION, HOST TREES

206 Hosomi, A.; Saito, M.; Sakurai, H.
1979. **2-trimethylsilylmethyl-1,3-butadiene as a novel reagent for isoprenylation. New access to ipsenol and ipsdienol, pheromones of *Ips* paraconfusus.** Tetrahedron Letters 5:429-432. 20 refs.
Reports the prepartion and use of a reagent for synthesizing ipsenol and ipsdienol.
SYNTHETIC PHEROMONES, IPSENOL, IPSDIENOL

207 Houser, J.S.
1931. **Effect [of the 1930 drought] on shade tree and forest insects.** J. Econ. Entomol. 24:657-658.
*Ips grandicollis* and *I. calligraphus* were problems in red pine platations in southern Ohio during the abnormally dry summer of 1930.
PHYSICAL FACTORS, OUTBREAK, DROUGHT

208 Houser, J.S.
1932. **Insect pests and drouth.** Ohio Agric. Exp. Stn. Bull. 497:70-71.
The outbreak of *Ips grandicollis* is red pine during the late summer and fall of 1930 (Houser 1931) subsided with the return of favorable soil moisture conditions in the spring of 1931.
OUTBREAK, DROUGHT

209 Hoyt, A.S.
1952. **Turpentine beetles become vicious tree killers.** U. S. Dep. Agric., Rep. of the Chief of the Bureau of Entomology and Plant Quarantine 1951:16-17.
Briefly mentions that in recent years *Dendroctonus terebrans* had become a primary tree killer in the deep South, particularly in naval stores operations and following timber harvest.
DAMAGE

210 Hoyt, A.S.
1953. **Benzene hexachloride controls turpentine beetle on pines.** U. S. Dep. Agric., Rep. of the Chief of the Bureau of Entomology and Plant Quarantine 1952:40.
Mentions that water suspensions and oil solutions of BHC were found to be effective in preventing and controlling *Dendroctonus terebrans* infestations in standing trees.
DAMAGE, CHEMICAL CONTROL

211 Hoyt, A.S.
1954. **Same recommendations continue for black turpentine beetle control.** U. S. Dep. Agric., Rep. of the Chief of the Bureau of Entomology and Plant Quarantine 1953:22.
Breeding of *Dendroctonus terebrans* in freshly cut stumps can be prevented with 10% BHC dust and 0.25 or 0.50% solutions in oil. Stumps lose their attractiveness to beetles before the insecticide loses its toxicity.
CHEMICAL CONTROL

212 Hughes, P.R.
1974. **Myrcene: a precursor of pheromones in *Ips* beetles.** J. Insect Physiol. 20:1271-1275. 2 tabs, 1 fig, 7 refs.
Demonstrates that the host tree monoterpene myrcene can serve as a precursor of the pheromones ipsdienol and ipsenol. *I. avulsus* produces ipsdienol upon simple exposure to myrcene. *I. grandicollis* and *I. calligraphus* require feeding before producing ipsenol and ipsdienol respectively.
METABOLISM, PHEROMONES, TERPENES, MYRCENE, IPSDIENOL, IPSENOL

213 Hughes, P.R.
1975. **Pheromones of *Dendroctonus*: Origin of alpha-pinene oxidation products present in emergent adults.** J. Insect Physiol. 21:687-691. 1 tab, 4 refs.
Larvae and adults, but not pupae, of *Dendroctonus terebrans* and *D. frontalis* can metabolize alpha-pinene to produce trans-verbenol.
PHYSIOLOGY, METABOLISM, PHEROMONES, ALPHA-PINENE

214 Hunter, P.E.; Davis, R.
1963. **Observations on *Histiostoma gordius* (Vitz.) (Anoetidae) and other mites associated with *Ips* beetles.** Proc. Entomol. Soc. Wash. 65:287-293. 1 tab, 8 refs.
Reports briefly on 6 species of mites associated with 8 species of *Ips*. *Histiostoma gordius* (Vitz.), the most commonly encountered mite, is apparently a fungus or yeast feeder.
MITES

215 Hunter, P.E.
1964. **Five new mites of the subfamily Ereynetinae (Acarina: Ereynetidae).** Fla. Entomol. 47:181-193. 1 tab, 5 figs, 9 refs.
The *Ereynetoides* sp. mite reported from galleries of *Ips calligraphus* by Hunter and Davis (1963) is described as ***E**. scutulis*.
MITES

216 Hunter, P.E.; Moser, J.C.
1968. ***Pseaudoparasitus thatcheri* n. sp. (Acarina: Dermanyssidae, Laelapinae) associated with southern pine beetles.** Fla. Entomol. 51:119-123. 2 figs, 3 refs.
The taxonomic description of a mite found in dry boring dust after *Dendroctonus frontalis* and *Ips* spp. had emerged from loblolly pines.
MITES

217 Hurlbutt, H.W.
1967. **Digamasellid mites associated with bark beetles and litter in North America.** Acarologia 9:497-534. 120 figs, 26 refs.
Among the 11 species of *Digamasellus* described in this paper, *D. isodentatus* was found in the galleries of *Ips avulsus* and *D. varipunctatus* came from bark containing galleries of *I. avulsus* and *I. calligraphus*. *Longoseius cuniculus* was phoretic on *I. calligraphus*. *D. neodisetus* was collected from galleries of *Dendroctonus terebrans*.
MITES

218 Jackson, L.W.R.; Thompson, G.E.; Lund, H.O.
1954. **Forest diseases and insects of Georgia's trees.** Georgia Forestry Commission, Macon, Ga. 40 P.
Pages 26 and 27 have brief descriptions of the biologies and control recommendations for the black turpentine and *Ips* engraver beetles.
ATTACK, DAMAGE, CHEMICAL CONTROL, CULTURAL CONTROL

219 Jones, G.D.; Ford, J.E.
1954. ***Ips* engraver beetles in North Carolina.** N. Car. Agr. Ext. Serv., Ext. Folder No. 108. 7 p., illus.
Discusses the identification, life history, and injury of the 3 *Ips* beetles along with methods for preventing and controlling infestations.
LIFE HISTORY, DAMAGE, APPLIED CONTROL, EXTENSION BULLETIN

220 Jordan, C.R.; Dyer, C.D.
1956. **The black turpentine beetle and its control.** Ga. Agric. Ext. Circ. 404. 12 p.
A well-illustrated extension publication emphasizing control of the black turpentine beetle with preventive and remedial sprays of BHC in fuel oil or water.
BIOLOGY, ASSOCIATES, BEHAVIOR, DAMAGE, CHEMICAL CONTROL, BHC, PREVENTIVE SPRAYING

221 Jouvenaz, D.P.
1968. **Relations of the bacterium *Serratia marcescens* Bizio to the bark beetle *Ips calligraphus* (Germar) (Coleoptera: Scolytidae) in Florida.** Gainesville, Florida: Univ. Fla. vi + 51 p. 6 tabs, 8 figs, 46 refs. M. Sci. Thesis.
See Jouvenaz and Wilkinson 1970.
BACTERIA, MICROORGANISMS, PATHOLOGY

222 Jouvenaz, D.P.; Wilkinson, R.C.
1970. **Incidence of *Seratia marcescens* in wild *Ips calligraphus* populations in Florida.** J. Invertebr. Pathol. 16:295-296. 1 tab, 1 fig, 3 refs.
The bacterium *Seratia marcescens* was isolated from 75% of the teneral adults and 17% of the parent adults in wild *Ips calligraphus* populations. Rearing experiments showed a low rate of carry-over from parent to $F_1$ adults.
BACTERIA, MICROORGANISMS, PATHOLOGY

223 King, W.E.
1966. **The biological impact of the checkered beetles (Coleoptera: Cleridae) on populations of *Ips* bark beetles (Coleoptera: Scolytidae).** Clemson, SC: Clemson Univ. vii + 92 p. 13 tabs, 6 plates, 2 figs, 12 refs. Dissertation. Available from University Microfilms, Ann Arbor, MI. Order no. 67-6960.
See King and Fox 1969.
PREDATORS

224 King, W.E.; Fox, R.C.
1969. **Notes on biology of clerid beetles that attack *Ips* spp. in upper South Carolina.** Ann. Entomol. Soc. Am. 62:924-925. 2 figs, 3 refs.
*Enoclerus nigripes* (Say) and *E. nigrifrons* (Say) were captured in traps baited with bolts freshly infested by *Ips grandicollis*. In laboratory studies the clerid adults consumed about one *I. grandicollis* and two to three *I. avulsus* adults per day. Oviposition was irregular in frequency and number, averaging about two eggs per day. First instar clerids introduced into *I. grandicollis* galleries were observed feeding on eggs and bark beetle larvae, proving the clerids' role as predators of *Ips* spp.
PREDATORS

225 Kinn, D.N.
1971. **The life cycle and behavior of *Cercoleipus coelonotus* (Acarina: Mesostigmata) including a survey of phoretic mite associates of California Scolytidae.** Univ. Calif. Publ. Entomol. 65:1-66. 28 tabs, 5 figs, 161 refs.
A survey of mites associated with California Scolytidae identified at least 24 species of mites associated with 37 species of bark beetles. Mites associated with *Ips calligraphus* were *Digamasellus quadrisetus*, an unidentified uropodid, *Pygmephorus* sp., *Histiogaster* nr. *arborsignum*, and *Histiostoma* sp. A detailed investigation of the life cycle and behavior of *Cercoleipus coelonotus*, frequently phoretic on adult *Ips confusus* and *I. montanus*, showed that this mite preys primarily on nematode parasites of bark beetles and thus may reduce mortality of beetle broods.
MITES, PREDATORS, ASSOCIATES

226 Kislow, C.J.; Jones, A.S.; Hastings, F.L.
1979. **Screening modern insecticides for control of black turpentine beetles and *Ips* species.** Pp 65-68 in Esser, M.H., ed. Sixth Annu. Lightwood Res. Conf. Proc.; 1979 January 17-18; Atlanta, Ga. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 151 p.
Presents preliminary data from the screening of 10 insecticides for the preventive and remedial control of *Ips* spp. and the black turpentine beetle in southern pines.
CHEMICAL CONTROL, INSECTICIDE EVALUATION, CHLORPYRIFOS, FENITROTHION

227 Kobayshi, T.; Guzman, E.D. de; Quintos, M.M.
1977. **Some observations on the microfungi of *Ips*-infested *Pinus kesiya* in the Philippines.** Pterocarpus 3(2):19-24. 3 tabs, 4 figs, 2 refs.
*Ceratocystis* sp. was the dominant fungus isolated from wood chips extracted from *Ips*-infested *Pinus kesiya*. Eight additional genera of fungi were also identified.
FUNGI

228 Koch, P.
1972. **Utilization of the southern pines.** U. S. Dep. Agric. Agric. Handb. 420, 734 p.
Contains a brief summary of the biology and control of the 3 *Ips* species on pages 695-698 and one paragraph about *Dendroctonus terebrans* on page 687.
BIOLOGY, DAMAGE, CONTROL

229 Kowal, R.J.; Coyne, J.F.
1951. **The black turpentine beetle can kill trees.** AT-FA Journal 13(9):7,14-15.
A good discussion of possible causes of black turpentine beetle outbreaks in the late 1940's and 1950's and information on beetle tree-attack symptoms. The article was written before insecticidal control of *D. terebrans* had been thoroughly investigated; consequently most of the chemical control recommendations were preliminary.
LIFE HISTORY, BEHAVIOR, CHEMICAL CONTROL, BHC, CHLORDANE

230 Kowal, R.J.
1955. ***Ips* beetles are killing pines: What shall we do about it?** U. S. For. Serv. Southeast. For. Exp. Stn. Res. Note 81. 2 p.
Presents recommendations to woodland owners for reducing beetle populations and timber losses.
CHEMICAL CONTROL, CULTURAL CONTROL

231 Kowal, R.J.; Rossoll, H.
1958. **Beetles in your pines? How good cutting practices and management stop beetles from killing your timber.** U. S. For. Serv. Southeast. For. Exp. Stn., Asheville, NC. 28 p.
A well-illustrated and easy reading guide for forest owners which provides information on detecting and identifying the bark beetles infesting southern pines, methods for preventing attack, and cultural and chemical control methods to use when such controls are necessary.
SURVEYS, CHEMICAL CONTROL, CULTURAL CONTROL

232 Kucera, D.R.; Ward, J.D.; Wallace, H.N.
1970. **Effectiveness of chemical control for the black turpentine beetle in central Louisiana.** J. Econ. Entomol. 63:104-106. 2 tabs, 1 fig, 3 refs.
Results of this 3 year pilot test were inconclusive but show a need for a sytematic and quantitative biological evaluation technique to decide for or against control of black turpentine beetle. The authors suggest that observations made in future biological evaluations include: percent trees attacked, percent tree mortality, and proportion of successful attacks out of total attacks per tree. Number of attacks per tree was found in this test to be a poor prediction of tree mortality. Even though beetle populations were very low during the test, results point to the need for research to develop methods for determining under what conditions stumps require insecticidal sprays following logging.
SAMPLING, DAMAGE, CHEMICAL CONTROL

233 Kudon, L.H.; Berisford, C.W.

1980. **Influence of brood hosts on host preferences of bark beetle parasites.** Nature 283:288-290. 1 fig, 18 refs.

Field cage studies showed that parasites of *Dendroctonus frontalis*, *Ips grandicollis* and *Phloeosinus dentatus* tended to respond in greatest numbers to the species of host from which they emerged, an apparent demonstration of Hopkins' host selection principle. The ability of the parasites to switch to more abundant alternate hosts when populations of preferred hosts decrease is advantageous to the parasites and may reduce the impact of parasites on declining populations.

PARASITES, PARASITE BIOLOGY, HOST FINDING, HOPKINS' HOST SELECTION PRINCIPLE

234 Kudon, L.H.; Berisford, C.W.

1981. **Identification of host origin of parasites of bark beetles (Coleoptera: Scolytidae) by fatty acid composition.** Can. Entomol. 113:205-212. 3 tabs, 3 figs, 16 refs.

Presents gas-liquid chromatograms of methylated fatty acids for the 3 *Ips* species, several other beetles, and 5 hymenopterous parasites, demonstrating the usefulness of lipid patterns for determining the host origin of bark beetle parasites. [Important note: Several figures are incorrect in the original paper. Contact the authors for the correct figures].

PARASITES, PHYSIOLOGY

235 Kulman, H.M.

1964. **Pitch defects in red pine associated with unsuccessful attacks by *Ips* spp.** J. For. 62:322-325. 1 fig, 10 refs.

Illustrates and discusses pitch pockets, streaks, and bark scars associated with unsuccessful attacks by *Ips grandicollis*.

DAMAGE

236 Lacordaire, T.

1866. **Famille LXII, Scolytidae.** Histoire naturelle des insectes, genera des coleopteres 7:349-398.

The description of the genus *Dendroctonus* (pp. 360-361) lists *D. terebrans* as one of the North American species. [The description of *Tomicus* ( = *Ips*) contains no information on North American species.]

TAXONOMY, MORPHOLOGY, LIFE HISTORY, DISTRIBUTION

237 Lanier, G.N.; Cameron, E.A.

1969. **Secondary sexual characters in the North American species of the genus *Ips* (Coleoptera: Scolytidae).** Can. Entomol. 101:862-870. 2 tabs, 10 figs, 32 refs.

Describes previously unreported sex-specific characters, summarizes those published previously, and evaluates the accuracy of each character individually for 32 species of North American *Ips*. Characters examined were the frons, vertex of the head, protibial spurs, and declivital armature. [See Lanier 1972 for additional information on *I. avulsus* characters.]

MORPHOLOGY

238 Lanier, G.N.

1970. **Biosystematics of North American *Ips* (Coleoptera: Scolytidae), Hopping's group IX.** Can. Entomol. 102:1139-1163. 4 tabs, 51 figs, 101 refs.

Biosytematic studies of *Ips grandicollis* and 6 other species in Hopping's group IX are reported. This study employed controlled matings, karyology, and examination and measurement of morphological characters.

TAXONOMY, MORPHOLOGY, KARYOLOGY

239 Lanier, G.N.

1971. **Cytoplasmic incompatibility and breeding isolation in bark beetles (Coleoptera: Scolytidae).** Can. J. Genet. Cytol. 13:160-163. 2 tabs, 15 refs.

This paper argues that nuclear-controlled cytoplasmic incompatibility, rather than unlike chromosomes, is an important mechanism in the reproductive isolation of closely related species. Data presented include the percent hatch of eggs produced in pairings of *Ips calligraphus, I. ponderosae*, their first generation offspring, and *I. interstitialis*.

GENETICS, CYTOPLASMIC INCOMPATIBILITY

240 Lanier, G.N.

1972. **Biosystematics of the genus *Ips* (Coleoptera: Scolytidae) in North America. Hopping's groups IV and X.** Can. Entomol. 104:361-388. 5 tabs, 32 figs, 78 refs.

Morphological and karyological data indicated the validity of Hopping's group IV which includes *Ips avulsus* . In group X, *I. interstitialis* is removed from synonymy with *I. calligraphus*. Two subspecies are described: *I. c. calligraphus* which inhabits the eastern United States and Canada plus as small area of California where it was apparently introduced; *I. c. ponderosae*, distributed from Arizona and New Mexico northward to the Dakotas and Montana.

TAXONOMY, MORPHOLOGY, KARYOLOGY

241 Lanier, G.N.; Burkholder, W.E.

1974. **Pheromones in speciation of Coleoptera.** Pages 161-189 in Birch, M.C., ed. Pheromones. New York: American Elsevier Publ. Co. 495 p. 8 tabs, 1 fig, 95 refs.

Examines the subject of species-specificity of attractant pheromones in Coleoptera, the evolution of pheromone differences, and the role of pheromones in speciation. *Dendroctonus terebrans* and the three southeastern *Ips* species are included in the review and discussion.

PHEROMONES, EVOLUTION, SPECIATION

242 Lanier, G.N.; Wood, D.L.

1975. **Specificity of response to pheromones in the genus *Ips* (Coleoptera: Scolytidae).** J. Chem. Ecol. 1:9-23. 8 tabs, 28 refs.

Reports on laboratory and field tests of pheromone-response specificity for 17 *Ips* spp. Suggests that specificity of pheromone systems is an important mechanism for minimizing interspecific competition and preventing interspecific mating among sympatric species such as *Ips grandicollis, I. calligraphus*, and *I. avulsus.*

AGGREGATION PHEROMONES, REPRODUCTIVE ISOLATION, SPECIFICITY, CROSS-ATTRACTION

243 Lanier, G.N.

1981. **Cytotaxonomy of *Dendroctonus*.** Pages 33-66 in Stock, M. W., ed. Application of genetics and cytology in insect systematics and evolution. Proc. Symp. Natl. Meeting of the Entomol. Soc. Amer., Atlanta, 1-2 Dec 1980. Moscow, ID: Forest, Wildl. and Range Exp. Stn., Univ. Idaho. 152 p. 1 tab, 24 figs, 24 refs.

The diploid chromosome number for *Dendroctonus terebrans* is 26 and the male meiotic formula is 12AA + $Xy_p$. The large bivalent no. 1 in the specimen examined made this species chromosomally unique among the 14 species reported in this study.

TAXONOMY, KARYOLOGY

244 Lapis, E.B.; San Valentin, H.O.

1979. **Field response of *Ips* (*Ips calligraphus* Germar) to synthetic aggregation pheromones and other attractants.** Sylvatrop Philipp. For. Res. Journal 4(4):223-229. 3 tabs, 1 fig, 13 refs.

The combination of cis-verbenol and ipsdienol was highly attractive to *Ips calligraphus* in the Philippines. Catches declined significantly when ipsenol was added to the traps.

AGGREGATION PHEROMONES, ANTIAGGREGATION PHEROMONES, IPSENOL, IPSDIENOL, CIS-VERBENOL, ETHANOL, HOST VOLATILES

245 Leach, J.G.; Orr, L.W.; Christensen, C.
1934. **The interrelationships of bark beetles and blue-staining fungi in felled Norway pine timber.** J. Agr. Res. 49(4):315-341. 1 tab, 13 figs, 20 refs.
Experiments demonstrated that blue-staining fungi were introduced into *Pinus resinosa* logs by *Ips grandicollis* and *I. pini* and that phoretic mites helped to spread the spores beneath the bark. New adults ingested perithecia and ascospores during their maturation feeding; the spores remained viable after passing through the beetles. Most transmission of the fungi occurs by spores adhering to the beetles. The authors consider the relationship as one of true symbiosis in which the fungi benefit by being transmitted and beetles benefit by reduced resin flow and a more favorable microenvironment beneath the bark.
FUNGI, YEASTS, MITES

246 Leach, J.G.
1938. **Insects in relation to diseases of shade and forest trees.** J. Econ. Entomol. 31:23-24.
A brief report of a motion picture presentation made at a symposium on the relationship between insects and plant disease. The film documents experiments proving that blue-stain fungi are introduced into pines by *Ips grandicollis* and *I. pini* (see Leach, 1934), illustrates the life histories of the organisms, and shows methods for controlling bark beetles.
FUNGI

247 LeBaron, W.
1871. **Means against larvae in timber; answers to correspondents.** Prairie Farmer, vol 42. [no page or date of issue given.].
Not seen. According to Hopkins (1909a, p. 157), the reference to *Dendroctonus terebrans* in this paper really refers to *D. valens*.

248 LeConte, J.L.
1868. **Appendix. [Synopsis of the Scolytidae of America north of Mexico.].** Trans. Am. Entomol. Soc. 2:150-178.
This appendix to Zimmermann's paper modified and expanded the Scolytid classification developed by Dr. Zimmermann. Among the many taxonomic changes, LeConte stated (p. 173) that *Dendroctonus valens* which he had described in 1860 from specimens collected in California was a synonym for *D. terebrans*. His genus *Tomicus* (pp. 162-164) included *Ips avulsus* and *I. calligraphus* as *T. avulsus* and *T. calligraphus*. *T. cacographus*, a new species, is now recognized as a junior synonym of *Ips grandicollis* (Eichhoff 1868).
TAXONOMY, MORPHOLOGY

249 LeConte, J.L.
1876. **Family IX. Scolytidae.** Pages 341-390 in J. L. LeConte and G. H. Horn, The Rhynchophora of America north of Mexico. Proc. Amer. Philos. Soc. 15:1-455.
Contains keys to the adults and brief descriptions of the North American bark beetles known and recognized at that time. *Ips avulsus* and *I. calligraphus* are discussed as *Tomicus avulsus* and *T. calligraphus* on pages 362-367. *Ips grandicollis* is included as *T. cacographus*. The description of *Dendroctonus terebrans* (p. 385) incorrectly includes *D. valens* LeConte as a synonym.
TAXONOMY

250 Lee, R.E.; Smith, R.H.
1953. **Killing of pine by the black turpentine beetle, its habits and control.** Assoc. South. Agr. Workers Proc. 50:105.
Briefly describes early tests in Mississippi and Florida to control the black turpentine beetle by spraying pine stumps with BHC, DDT, and chlordane.
DAMAGE, CHEMICAL CONTROL, APPLIED CONTROL, BHC, DDT, CHLORDANE

251 Lee, R.E.; Smith, R.H.
1955. **The black turpentine beetle, its habits and control.** U. S. For. Serv. South. For. Exp. Stn. Occasional Paper 138. 14 p. 5 figs, 5 refs.
One of the most comprehensive publications on the biology, behavior and control of *Dendroctonus terebrans*. Of particular value is the discussion of the chronological development of preventive and remedial insecticidal control tests conducted by the U.S. Forest Service. Recommendations for preventing BTB population build-up and applying direct control methods are covered in depth.
BIOLOGY, LIFE HISTORY, ECOLOGY, BEHAVIOR

252 Lee, R.E.; Coyne, J.F.
1955. **Suggested guides for detecting the black turpentine beetle.** Texas For. News 34(6):4-5.
An informative article about where, when, and how to look for black turpentine beetle infestations. The authors recommend making at least two regularly scheduled inspections following a stand disturbance, the timing depending on the month of disturbance.
BEHAVIOR, ATTACK, SURVEYS, STAND CONDITIONS, SITE FACTORS, INFESTATION SYMPTOMS

253 Lindquist, E.E.
1964. **Mites parasitizing eggs of bark beetles of the genus *Ips*.** Can. Entomol. 96:125-126.
A brief, general description of the biology of mites parasitizing bark beetle eggs.
MITES

254 Lindquist, E.E.; Hunter, P.E.
1965. **Some mites of the genus *Proctolaelaps* Berlese (Acarina: Blattisociidae) associated with forest insect pests.** Can. Entomol. 97:15-32. 35 figs, 18 refs.
*Proctolaelaps bickleyi*, *P. fiseri*, *P. hystricoides*, and *P. dendroctoni* were associated with galleries of *Ips calligraphus*. *P. dendrodroctoni* was also collected from *Ips avulsus* galleries. *P. hystrix* was the only species of this genus taken from galleries of *Dendroctonus terebrans*.
TAXONOMY, MITES, PREDATORS, BIOLOGICAL CONTROL

255 Lindquist, E.E.
1969. **Mites and the regulation of bark beetle populations.** Proc. 2nd Int. Congr. Acarology, Sutton Bonington, England, 1967, pp. 389-399. 1 tab, 66 refs.
Reviews published and current research on the mites associated with bark beetles and indicates the merits and course of further research.
REVIEW, MITES

256 Lindquist, E.E.
1969. **Review of holarctic tarsonemid mites (Acarina: Prostigmata) parasitizing eggs of ipine bark beetles.** Mem. Entomol. Soc. Can. No. 60. 111 p. 2 tabs, 77 figs, 8 maps, 72 refs.
The genus *Iponemus* (= feeding on *Ips*) is proposed and 24 species and subspecies are described, keyed, and illustrated. Relationships between the mites and the beetles and the role of egg parasitism in regulating beetle populations are discussed. *I. truncatus* Eurus, *I. confusus oriens*, and *I. c. calligraphi* are the mites reported from *Ips avulsus*, *I. grandicollis* and *I. calligraphus*, respectively.
MITES, PARASITES

257 Lindquist, E.E.
1969. **New species of *Tarsonemus* (Acarina: Tarsonemidae) associated with bark beetles.** Can. Entomol. 101:1291-1314. 10 refs.
Provides taxonomic descriptions, locality, and host records for 4 new species of mites in the genus *Tarsonemus*. *T. ips* is reported from *Ips*

*avulsus* and *I. calligraphus*. *T. subcorticalis* is reported from *I. grandicollis* and *I. calligraphus*.
MITES

258 Lindquist, E.E.
1971. **New species of Asciidae (Acarina: Mesostigmata) associated with forest insect pests.** Can. Entomol. 103:919-942. 47 figs, 12 refs.
*Gamasellodes rectiventris* was found under the bark of a pine previously infested by *Ips avulsus* and *I. calligraphus*.
MITES

259 Lorio, P.L.
1973. **Declining pines associated with bark beetle activity in Allen Parish, La.** U. S. For. Serv. Res. Note SO-163. 3 p. 3 tabs, 5 refs.
*Dendroctonus terebrans* infested one or more loblolly pines on 33 of 100 0.1-acre plots during a 30-month study of areas with declining trees; there was no evidence of other bark beetles on 24 of the 33 plots. *Ips* spp. infested trees on six plots; *D. frontalis* and *D. terebrans* were also present on four of these plots. *D. frontalis* occurred on a total of five plots. The author suggests that declining trees and *D. terebrans* attacks help to maintain *D. frontalis* populations during endemic periods of the latter species.
ECOLOGY, TREE PHYSIOLOGY, STRESS

260 Lorio, P.L.; Bennett, W.H.
1974. **Recurring southern pine beetle infestations near Oakdale, Louisiana.** U. S. For. Serv. Res. Pap. SO-90. 6 p. 2 tabs, 5 figs, 6 refs.
Contains a statement that *Dendroctonus terebrans* had been a problem in the area for many years prior to the first known *D. frontalis* activity.
OUTBREAK, DAMAGE, CHEMICAL CONTROL, APPLIED CONTROL, STAND CONDITIONS, SITE FACTORS

261 Lugger, Otto
1899. **Beetles injurious to fruit-producing plants.** Minn. Agr. Exp. Stn. Bull. 66:117.
Mentions that *Dendroctonus terebrans* [ = *D. valens*] is common in the pine forests of Minnesota and needs to be constantly fought.
ATTACK

262 Marchant, K.R.; Borden, J.H.
1976. **Worldwide introduction and establishment of bark and timber beetles (Coleoptera:Scolytidae and Platypodidae).** Simon Fraser Univ., Burnaby, B.C., Canada. Pest Management Papers No. 6. 76 p. 98 refs.
Lists 55 species of Scolytidae and 3 species of Platypodidae which are established outside their natural range, analyzes bilolgical, economic, geographic, and legal factors that influence introductions of exotic bark and timber beetles, and identifies selected species which represent threats of future introduction and significant economic impact. Reports that *Ips calligraphus* is established in California and the Philippines, and that *I. grandicollis* was introduced into Australia in 1943.
DISPERSAL, DISTRIBUTION, HOST TREES

263 Marsh, P.M.
1979. **Catalog of Hymenoptera in America north of Mexico. Family Braconidae.** Pages 144-295 in Karl V. Krombein et al., Catalog of Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, DC. 2735 pages in 3 volumes.
Confirmed Braconid parasites of the southeastern *Ips* spp. are *Coeloides pissodis* (Ashmead) 1889 for *Ips grandicollis* and *I. calligraphus*, *Dendrosoter sulcatus* Muesebeck 1938 for *I. avulsus*, and *Spathius pallidus* Ashmead 1893 for *I. avulsus* and *I. grandicollis*.
PARASITES

264 Mason, R.R.; Muhonen, J.M.; Swartz, J.N.
1963. **Water sprayed storage of southern pine pulpwood.** Tappi 46:233-240. 6 tabs, 17 figs, 22 refs.
Continuous water spraying for six months effectively protected large volumes of stored pulpwood from *Ips* engraver beetles, wood borers, and fungi. The effects of wet and dry storage on wood and wood pulp quality and yields are compared.
ECONOMICS, DAMAGE, FUNGI

265 Mason, R.R.
1965. **The relation of slash diameter and *Ips* brood development.** Hiwassee Land Co., Calhoun, TN. Hiwassee For. Res. Note 15. 5 p. 1 tab, 1 fig.
*Ips avulsus* and *I. grandicollis* attacks and emerging brood per unit area were about the same for logging slash averaging 2,3,4 and 5 inches in diameter.
BIOLOGY, HOST TREES

266 Mason, R.R.
1966. **Dynamics of *Ips* populations after summer thinning in a loblolly pine plantation: with special reference to host tree resistance.** Ann Arbor, Michigan. Univ. Michigan. vii + 152 p. 13 tabs, 40 figs, 201 refs. Dissertation. Available from University Microfilms, Ann Arbor, Michigan. Order no. 66-14,558.
See Mason 1969, 1970, and 1971.
ECOLOGY, POPULATION DYNAMICS, SAMPLING, BEHAVIOR, FLIGHT, BROOD MATERIAL, HOST TREES, STAND CONDITIONS, SOIL MOISTURE, OLEORESIN PRODUCTION

267 Mason, R.R.
1969. **Behavior of *Ips* populations after summer thinning in a loblolly pine plantation.** For. Sci. 15:390-398. 5 figs, 15 refs.
Describes a study conducted in an 11-year-old loblolly plantation in Tennessee. The author concludes that beetles emerging from slash in summer thinnings may sometimes be a hazard to old trees or trees on poor sites, but are unlikely to be a serious threat to healthy loblolly pines in pulpwood stands.
POPULATION DYNAMICS, DISPERSAL, FLIGHT, BEHAVIOR, ECOLOGY, BROOD MATERIAL

268 Mason, R.R.
1970. **Comparison of flight aggregation in two species of southern *Ips* (Coleoptera: Scolytidae).** Can. Entomol. 102:1036-1041. 2 figs, 20 refs.
Window trap data and three indices of dispersion were used to quantify the relative aggregation of *Ips avulsus* and *I. grandicollis* infesting the slash following a summer thinning of a young loblolly pine plantation in southeastern Tennessee. The author concludes that the higher degree of flight aggregation by *I. avulsus* may partly explain why it is more frequently a killer of loblolly pines than is *I. grandicollis*.
ECOLOGY, SAMPLING, BEHAVIOR, FLIGHT, NEGATIVE BINOMIAL, I-DELTA, TAYLOR'S POWER LAW

269 Mason, R.R.
1971. **Soil moisture and stand density affect oleoresin exudation flow in a loblolly pine plantation.** For. Sci. 17:170-177. 1 tab, 3 figs, 16 refs.
Oleoresin exudation flow (OEF) from 12-year-old loblolly pines in southeastern Tennessee decreased with decreasing soil moisture and increasing stand density. Thinning increased the flow rate on residual trees. These results are discussed in relation to attacks by *Ips* spp.

HOST TREES, SOIL MOISTURE, STAND CONDITIONS, OLEORESIN PRODUCTION

270 Massey, C.L.
1974. **Biology and taxonomy of nematode parasites and associates of bark beetles in the United States.** U. S. For. Serv. Agric. Handb. No. 446. 233 p.
Presents the biology and taxonomy of 32 nematode parasites and 114 nematode associates of 45 species of bark beetles. *Parasitylenchus avulsi* parasitizes *Ips avulsus*, and *Parasitaphelenchus procerus* parasitizes *I. calligraphus*. *Contortylenchus grandicollis* parasitizes both *I. calligraphus* and *I. grandicollis*. *Contortylenchus terebranus* is a new species listed as a parasite of *Dendroctonus terebrans*.
NEMATODES, PARASITES, ASSOCIATES

271 McCambridge, W.F.; Kowal, R.J.
1957. **Forest insect conditions in the Southeast during 1956.** U. S. For. Serv. Southeast. For. Exp. Stn., Stn. Pap. 76. 7 p.
Discusses timber acreages and volumes affected by the southern pine beetle, pine engraver beetles, and the black turpentine beetle from Virginia to Florida in 1956. Bark beetle control activity in the various states is described briefly.
DAMAGE, SURVEYS, CHEMICAL CONTROL, APPLIED CONTROL

272 McCowan, V.F.
1961. **Bark beetle conditions in timber damaged by hurricane Donna.** Fla. For. Serv., Tallahassee, Fla. Mimeo Rep. 1 p.
A January 1961 survey of slash pine stands damaged by hurricane Donna showed no evidence of bark beetle problems where salvage operations were thorough and complete. *Ips grandicollis* was the most prevalent species in unsalvaged pulpwood stands and the nearly mature brood posed a threat to injured trees. *I. calligraphus* and *I. grandicollis* broods were abundant and nearly mature in the sawtimber and pole-sized trees. Forest managers were advised to conduct salvage operations where feasible and to continue surveillance of wind damaged areas for at least 6 months.
PHYSICAL FACTORS

273 McGraw, J.R.; Farrier, M.H.
1969. **Mites of the superfamily Parasitoidea (Acarina: Mesostigmata) associated with *Dendroctonus* and *Ips* (Coleoptera: Scolytidae).** North Carolina Agric. Exp. Stn. Tech. Bull. No. 192. 162 p. 1 tab, 125 figs, 164 refs.
Contains keys to and descriptions of 35 species of mites associated with *Dendroctonus* and *Ips* beetles in the southeastern United States.
MITES, MITE BIBLIOGRAPHY, MITE TAXONOMY

274 Merkel, E.P.; Heller, R.C.; Aldrich, R.C.; Bailey, W.F.
1955. ***Ips* pine engraver beetle epidemic in southern Georgia —an aerial detection and damage appraisal survey.** U. S. For. Serv. Southeast. For. Exp. Stn. Forest Insect Survey Rep. No. 1. 9 p. 2 tabs, 1 fig, 2 refs.
A line-strip aerial survey of 37 South Georgia counties in January 1955 estimated the timber loss during the preceeding 6 months to be 8,212,000 cu. ft., due primarily to *Ips* spp. This is the most severe *Ips* outbreak recorded in the South.
OUTBREAK, DAMAGE, SURVEYS

275 Merkel, E.P.; Kowal, R.J.
1956. **Forest insect conditions in the Southeast during 1955.** U. S. For. Serv. Southeast. For. Exp. Stn. Paper No. 67:4-6.
Timber losses in South Georgia and North Florida during 1955 were estimated to be 119 million bd. ft. and 190 thousand cords due to *Ips* species and 37 million bd. ft. due to the black turpentine beetle.
OUTBREAK, DAMAGE, SURVEYS, CHEMICAL CONTROL, APPLIED CONTROL, TIMBER LOSSES

276 Merkel, E.P.
1977. **Three insecticides reduce tree mortality and insect attacks of paraquat-treated slash pines.** Page 19 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1977 January 18-19; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 193 p.
A 2% aqueous emulsion of lindane was the only one of three insecticides tested which completely prevented *Ips* spp. and black turpentine beetle attacks for six months on paraquat-treated slash pines in Florida.
CHEMICAL CONTROL, PARAQUAT, LIGHTWOOD INDUCTION, LINDANE, CHLORPYRIFOS, CHLORPYRIFOS-METHYL

277 Merkel, E.P.
1978. **Effect of season on paraquat application and different insecticides on bark beetle-caused slash pine mortality.** Page 8 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1977 January 18-19; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 193 p.
Slash pines treated with 4% paraquat aqueous solution applied to a 1/3-circumference, horizontal, bark-streak wound, and not sprayed with insecticides, sustained higher percentages of tree mortality following spring/summer paraquat applications than fall/winter applications, e.g., April - 73%; June - 63%; November - 15%; February - 7%. In a series of insecticide evaluation field tests, 1- and 2-percent lindane water emulsions consistently gave greater protection to paraquat-treated trees from *Ips* spp. and black turpentine beetle attack than chlorpyrifos, chlorpyrifos-methyl, carbaryl, phosmet, and fenitrothion.
CHEMICAL CONTROL, PARAQUAT, LIGHTWOOD INDUCTION, CHLORPYRIFOS, CHLORPYRIFOS-METHYL, CARBARYL, PHOSMET, FENITROTHION

278 Merkel, E.P.
1979. **Field trial of lindane, phosmet, and fenitrothion to prevent insect-caused mortality of paraquat-treated slash pines.** U. S. For. Serv. Southeast. For. Exp. Stn. Res. Note SE-278. 4 p.
A field test in Florida showed that lindane was superior to phosmet and fenitrothion for protecting paraquat-treated slash pines from bark beetles.
CHEMICAL CONTROL, PARAQUAT, LINDANE, FENITROTHION, PHOSMET

279 Merkel, E.P.
1981. **Control of the black turpentine beetle.** Georgia Forestry Commission, Macon, Ga. Ga. For. Res. Paper 15. 4 p., illus.
An illustrated guide to black turpentine beetle control with emphasis on insecticide application. Includes information on beetle attack behavior, recognition of attack symptoms, and insect's life history.
LIFE HISTORY, BEHAVIOR, ATTACK, CHEMICAL CONTROL

280 Merkel, E.P.; Clark, E.W.
1981. **Insecticides for preventing insect-caused mortality of paraquat-treated slash pines.** U. S. For. Serv. Southeast. For. Exp. Stn. Res. Paper SE-219. 3 tabs, 10 refs.
This research substantiates earlier findings by Hertel, Williams, and Merkel (1977) that slash pines treated with paraquat in the spring and summer are more likely to suffer high mortality than those treated in fall and winter. Lindane performed more effectively in the field as a preventative bark beetle insecticide than chlorpyrifos, chlorpyrifos-methyl and carbaryl. Recommendations are given which would minimize, or even eliminate, the need for insecticide application following paraquat treatment of slash pine.
LIGHTWOOD INDUCTION, ATTACK, CHEMICAL CONTROL, IPM, STRESS, TREE MORTALITY, PARAQUAT, WOOD BORERS, LINDANE, CARBARYL, CHLORPYRIFOS, CHLORPYRIFOS-METHYL

281 Mignot, E.C.
1966. **The biology and effectiveness of two species of predators (*Temnochila virescens* Mann. and *Thanasimus dubius* Fab.) for the control of bark beetles.** Durham, NC: Duke Univ. School of Forestry. vii + 72 p. 18 tabs, 27 figs, 13 refs. Thesis.
See Mignot and Anderson 1969, 1970.
PREDATORS, PREDATOR BIOLOGY, PREDATOR DEVELOPMENT

282 Mignot, E.C.; Anderson, R.F.
1969. **Bionomics of the bark beetle predator, *Thanasimus dubius* Fab. (Coleoptera: Cleridae).** Entomol. News 80:305-310. 4 tabs, 4 refs.
Laboratory studies of *Thanasimus dubius* at 5 constant temperatures from 20 to 37 deg C showed that this bark beetle predator develops most rapidly and has highest survival at 25 deg C. Greatest egg production occurs at 30 and 25 deg C. The Clerid adults were observed on bark beetle infested trees during the spring, summer and fall, but immature predators were found only in the spring and fall. The authors suggest that *Temnochila virescens* destroyed the clerid larvae during the summer.
PREDATORS, PREDATOR BIOLOGY, PREDATOR DEVELOPMENT

283 Mignot, E.C.; Anderson, R.F.
1970. **Bionomics of the bark beetle predator, *Temnochila virescens* Mann. (Coleoptera: Ostomidae).** Entomol. News 81:85-91. 4 tabs, 3 refs.
*Temnochila virescens* was reared at 5 constant temperatures and provided with *Ips* spp. as prey. Development was most rapid at 30 deg. C, with an egg-to-adult time of 109 days. Mean longevity of adults and total egg production were also greatest at this temperature, being 179 days and 216 eggs per female, respectively. Field observations found *T. virescens* only in those trees colonized by bark beetles during the summer months; the Clerid *Thanasimus dubius* was present in trees colonized during the spring and fall . The data indicate that *T. virescens* has one generation per year in North Carolina, overwintering in the larval and imago stages.
PREDATORS, PREDATOR BIOLOGY

284 Miller, M.C.; Chappell, W.A.; Gamble, W.C.; Bridges, J.R.
1978. **Antiserum preparation for immunodiffusion in southern pine beetle predation studies.** U. S. For. Serv. Res. Note SO-233. 5 p. 2 tabs, 20 refs.
Reports the preparation, sensitivity, and selectivity of an antiserum to detect adult *Dendroctonus frontalis* serum in the predatory clerid *Thanasimus dubius*. The antiserum also reacts positively with antigens of *D. terebrans, Ips grandicollis* and *I. calligraphus*.
PREDATORS

285 Miller, M.C.; Chappell, W.A.; Gamble, W.C.; Bridges, J.R.
1979. **Evaluation of immunodiffusion and immunoelectrophoretic tests using a broad spectrum anti-adult southern pine beetle serum.** Ann. Entomol. Soc. Am. 72:99-104. 1 tab, 3 figs, 19 refs.
Evaluates six serological procedures for separating antigen-antibody systems in studies of insect predator-prey relationships. The antiserum developed for adult *Dendroctonus frontalis* antigens also reacted positively with extracts from adult *D. terebrans* and *Ips* avulsus.
PREDATION

286 Miller, M.C.
1979. **Development of a specific anti-adult southern pine beetle serum.** Misc. Publ. Entomol. Soc. Am. 11:35-53. 4 tabs, 3 figs, 23 refs.
Summarizes several earlier papers on the development of an antiserum for distinguishing antigens of *Dendroctonus frontalis* adults from the antigens of *D. terebrans, Ips avulsus, I. grandicollis*, and *I. calligraphus*.
PREDATORS, PREDATION

287 Miller, M.C.
1979. **Preparatory immunodiffusion for production of specific anti-adult southern pine beetle serum.** Ann. Entomol. Soc. Am. 72:820-825. 1 tab, 11 figs, 19 refs.
Discusses the feasibility of producing antiserum specific for adult *Dendroctonus frontalis* antigens by preparatory immunodiffusion. Previous problems of crossreactions with *D. terebrans* and *Ips* spp. serum have been overcome.
PREDATION

288 Miller, M.C.
1981. **Evaluation of enzyme-linked immunosorbent assay of narrow- and broad-spectrum anti-adult southern pine beetle serum.** Ann. Entomol. Soc. Am. 74:279-282. 2 figs, 4 refs.
The enzyme-linked immunosorbent assay is more sensitive than previously reported techniques for determination of predator-prey feeding relationships. The technique will distinguish among *Dendroctonus frontalis, D. terebrans*, and *Ips* spp., but will not distinguish among the three *Ips* species.
PREDATION, PHYSIOLOGY, ANTIGENS, ANTISERA

289 Mizell, R.F.; Nebeker, T.E.
1982. **Preference and oviposition rates of adult *Thanasimus dubius* (F.) on three prey species.** Environ. Entomol. 11:139-143. 5 tabs, 22 refs.
Laboratory experiments demonstrated that hungry adults of *Thanasimus dubius* consumed *Ips avulsus* and *Dendroctonus frontalis* adults in proportion to the number encountered and in preference to the larger cowpea weevil, *Callosobruchus maculatus*. When offered large quantities of a single species for a 7-day period, the predator consumed a greater number of the smallest species, *I. avulsus*. Females maintained on *I. avulsus* produced fewer eggs per day, but with greater viability, than females reared solely on *D. frontalis*.
PREDATORS

290 Moore, G.E.
1972. **Southern pine beetle mortality in North Carolina caused by parasites and predators.** Environ. Entomol. 1:58-65. 4 tabs, 3 figs, 21 refs.
This paper deals primarily with parasites and predators as factors in *Dendroctonus frontalis* brood mortality. During the period covered by this investigation, many of the trees were attacked first by *Ips avulsus* in the upper portion of the tree, then by *D. frontalis* lower on the stem. The author concludes that *I. avulsus* was not a primary competitor, nor did it reduce the *D. frontalis* population.
MITES, PARASITES, PREDATORS

291 Moore, G.E.
1977. **BHC, Dowco 214, and dursban protect paraquat-treated trees from bark beetles.** Pages 20-24 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1977 January 18-19; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 193 p.
Reports preliminary results of a study to evaluate the effectiveness of three insecticides, each applied at two concentrations, to protect paraquat-treated loblolly pines from attack by *Dendroctonus terebrans* and *Ips calligraphus*.
CHEMICAL CONTROL, TREE MORTALITY, LIGHTWOOD INDUCTION, PARAQUAT

292 Moore, G.E.
1978. **Survival of *Ips* and *Dendroctonus terebrans* in pines**

**treated with paraquat by streak and dowel methods.** Pages 83-87 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.
*Ips calligraphus* and *Dendroctonus terebrans* successfully attacked, survived in, and emerged from paraquat-treated loblolly pines where either no insecticide or inadequate sprays were used as protectants. Tree mortality was attributed to the *Ips* beetles, even though the trees were first occupied by *D. terebrans*.
CHEMICAL CONTROL, LIGHTWOOD INDUCTION, PARAQUAT, DURSBAN, RELDAN, BHC

293 Moore, G.E.; Stubbs, J.; Outcalt, K.W.
1979. **Minimizing insecticide requirements in the paraquat induction of resinosis.** Pages 49-55 in Esser, M.H., ed. Sixth Annu. Lightwood Res. Conf. Proc.; 1979 January 17-18; Atlanta, Ga. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 151 p.
Reports preliminary results of a study to identify the combination of tree wounding method, season of paraquat application, and paraquat concentration that would minimize insecticide requirements while inducing adequate lightwood formation in loblolly pine.
CHEMICAL CONTROL, LIGHTWOOD INDUCTION, PARAQUAT, LINDANE, ETHREL

294 Moore, G.E.
1982. **Infestation pattern and survival of bark beetles in loblolly pines treated with paraquat.** U.S. For. Serv. Southeast. For. Exp. Sta. SE-233. 7 p. 2 tabs, 7 refs.
*Ips calligraphus* attacks on dominant and codominant trees were usually confined to the bole above the paraquat-treated bark streak; attacks away from the treated face were usually on intermediate and and suppressed trees. Brood production was generally greater on the side away from the paraquat treatment. Black turpentine beetles attacked beside and below, but not directly above, the paraquat application site. Trees treated in June and August were attacked more frequently than trees treated in November, but tree mortality was not severe enough to justify insecticidal protection from bark beetles.
SURVIVAL, DISTRIBUTION, LIGHTWOOD INDUCTION, PARAQUAT

295 Moore, K.R.
1979. **Distributions of three species of *Ips* bark beetles within southern pine beetle infestations.** Nacogdoches, Texas: Stephen F. Austin State Univ. iv + 39 p. 8 tabs, 6 figs, 44 refs. Thesis.
Flight traps showed *D. frontalis* most abundant at 6 to 10 meters, *I. avulsus* at 5 to 9 meters, and *I. grandicollis* at 1, 6, and 9 meters. Only a few *I. calligraphus* were caught. Hourly examination of sticky traps showed *D. frontalis* and *I. calligraphus* flying from midmorning through the afternoon. *I. grandicollis* was most abundant in early morning and late afternoon, while *I. avulsus* was most abundant in midafternoon.
STATISTICS, MEAN CROWDING, VERTICAL FLIGHT, DIURNAL FLIGHT

296 Morgan, F.D.
1967. ***Ips grandicollis* in South Australia.** Aust. For. 31: 137-155. 4 tabs, 7 figs, 25 refs.
Describes the biology and behavior of *Ips grandicollis* infestating *Pinus radiata*. Some host-insect relationships are different than in North America due to the absence of competitors and most parasites. There are two distinct types of attacks on trees: feeding attacks, apparently to replenish depleted food reserves, and breeding attacks. The establishment and survival of summer and fall populations is best in bark thicker than 0.15 in. (3.8 mm.).
FUNGI, YEASTS, NEMATODES, BIOLOGY, DISPERSAL, OVIPOSITION, HOST TREES, ADULT FEEDING, INTRASPECIFIC COMPETITION, FAT BODY, DEVELOPMENT TIME, TREE STRESS, BARK THICKNESS

297 Mori, K.
1976. **Synthesis of optically active forms of ipsenol, the pheromone of *Ips* bark beetles.** Tetrahedron 32:1101-1106. 23 refs.
Reports the procedure for synthesizing (S)-(-)-ipsenol, the enantiomer which is biologically active on *Ips grandicollis*.
SYNTHETIC PHEROMONES, PHEROMONE SYNTHESIS, IPSENOL

298 Moser, J.C.; Thatcher, R.C.; Pickard, L.S.
1971. **Relative abundance of southern pine beetle associates in east Texas.** Ann. Entomol. Soc. Am. 64:72-77. 1 tab, 20 refs.
Reports the density, height and season of occurrence for 96 insect species found associated with *Dendroctonus frontalis* during a 3 year study. *Ips* beetles were present in all months, but usually most numerous in late summer. *Ips avulsus* was the most plentiful of the 3 species. *Dendroctonus terebrans* occured in some of the southern pine beetle-infested trees, but was not recorded because the lowest sample bolts were collected at 17-18 ft above ground.
PARASITES, PREDATORS, ASSOCIATES

299 Moser, J.C.; Cross, E.A.; Roton, L.M.
1971. **Biology of *Pyemotes parviscolyti* (Acarina: Pyemotidae).** Entomophaga 16:367-379. 4 tabs, 6 figs, 12 refs.
*Pyemotes parviscolyti*, which normally preys on the bark beetle *Pityophthorus bisulcatus*, will prey on the brood of other Scolytids when gallery systems of the bark beetles overlap.
MITES, PREDATORS

300 Moser, J.C.; Roton, L.M.
1971. **Mites associated with southern pine bark beetles in Allen Parish, Louisiana.** Can. Entomol. 103:1775-1798. 1 tab, 58 refs.
Presents data on the relative abundance, seasonal and height distributions, insect associates, feeding habts, and geographic distribution of 96 species of mites collected from *Dendroctonus frontalis* infested loblolly pines. *Ips avulsus* and *I. calligraphus* each hosted 13 species of mites, *I. grandicollis* hosted 8 species, and *D. terebrans* hosted 7 species.
MITES

301 Moser, J.C.
1976. **Surveying mites (Acarina) phoretic on the southern pine beetle (Coleoptera: Scolytidae) with sticky traps.** Can. Entomol. 108:809-813. 2 figs, 10 refs.
Incidentally mentions that *Ips* and other beetles were occasionally captured along with *Dendroctonus frontalis* on sticky traps and that their presence made it impossible to ascribe definite phoretic associations for 6 of the 13 mite species collected in the study.
MITES, PARASITES, PHORESY, SURVEYS

302 Moser, J.C.; Browne, L.E.
1978. **A nondestructive trap for *Dendroctonus frontalis* Zimmerman (Coleoptera: Scolytidae).** J. Chem. Ecol. 4:1-7. 2 figs, 21 refs.
Describes a bucket trap for collecting *Dendroctonus frontalis*. Traps baited with frontalure also collected a large number of the clerid *Thanasimus dubius*, but few specimens of *Ips* spp. and other insects.
TRAPS, FRONTALURE

303 Moser, J.C.; Kielczewski, B.; Wisniewski, J; Balazy, S.
1978. **Evaluating *Pyemotes dryas* (Vitzhum 1923) (Acari: Pyemotidae) as a parasite of the southern pine beetle.** Int. J. Acar. 4:67-70. 5 refs.
Laboratory studies with the European parasitic mite demonstrated

that this species readily consumes *Dendroctonus frontalis* brood, but it is not phoretic on *D. frontalis, Ips avulsus, I. grandicollis* and *I. calligraphus*, or several other associated beetles. The use of this mite as a biological control agent of North American bark beetles is precluded unless a suitable phoretic host is found.
MITES

304 Moser, J.C.
1981. **Transfer of a *Pyemotes* egg parasite phoretic on western pine bark beetles to the southern pine beetle.** Internat. J. Acarol. 7:197-202. 3 figs, 6 refs.
Describes the biology of *Pyemotes giganticus* and attempts to rear this mite on southern bark beetles. Although phoretomorphs readily rode the *Ips* species and other bark beetles, the reluctance of this mite to attack immature bark beetles suggests that it would not be an effective biological control agent.
MITES, PARASITES, BIOLOGICAL CONTROL

305 Nelson, R.M.; Beal, J.A.
1929. **Experiments with bluestain fungi in southern pines.** Phytopathology 19(12):1101-1106. 1 tab, 6 refs.
Experiments were conducted with pitch and shortleaf pines to determine if the blue stain fungi, *Ceratostomella (Ceratocystis)*, or closely related fungi, were capable of killing trees when not associated with beetle attacks. The fungi were isolated from trees attacked by *Dendroctonus frontalis, D. terebrans*, and *Ips calligraphus* and from adult beetles. In culture the fungi associated with each of the three beetle species were readily distinguishable. Three wounding and fungal inoculation methods were tried. It was found that the fungi together with the wounding that accompanied inoculation caused most trees to die in a comparatively short time. The authors noted that *Dendroctonus terebrans*, because of its attack habits and longitudinal egg galleries at the base of trees, can inoculate only a relatively small part of the tree with bluestain.
FUNGI, TREE MORTALITY, BLUE STAIN FUNGI, ARTIFICIAL INOCULATION

306 Nix, L.E.
1976. **Paraquat induction of resin soaking in pines in the South Carolina Piedmont.** Pages 102-108 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1976 January 20-21; Jacksonville, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 154 p.
Shortleaf, slash, and loblolly pines were treated with paraquat applied to axe frill and bark face wounds during August 1974. Within 8 weeks, *Ips* spp. attacked 20, 90, and 100% of the trees treated with 0, 2, and 8% paraquat, respectively. Tree mortality was 40-60% in the 2% paraquat treatments and 80-100% in the 8% paraquat-treated trees. The author attributed the mortality to beetle attack, not toxicity of the paraquat.
LIGHTWOOD INDUCTION, PARAQUAT

307 Nunberg, M.
1974. **The occurrence of *Ips grandicollis* (Eichh.) (Coleoptera, Scolytidae) in Cuba.** Polskie Pismo Entomologiczne 44:735-736. 3 refs. [In English with Polish summary.]
Reports the 1970 collection of *Ips grandicollis* from *Pinus tropicalis* in Pinar del Rio province, Cuba. Lists several other *Ips* species which might occur in Cuba either as native or introduced species.
DISTRIBUTION, HOST TREES

308 Olivier, A.G.
1795. **Entomologie, ou Histoire Naturelle des Insectes. Coleopteres 4(78):6-7, plate 1: fig. 6a,b.** Paris: Lanneau, Imprimeur.
The original taxonomic description of *Dendroctonus terebrans* (Oliv.) as *Scolytus terebrans*. [In Latin and French.]
TAXONOMY

309 Ostmark, H.E.
1968. **Bark and ambrosia beetles (Coleoptera: Scolytidae and Platypodidae) attracted to an ultraviolet light trap.** Fla. Entomol. 51:155-157. 1 tab, 4 refs.
Lists 23 species of bark and ambrosia beetles collected at one ultraviolet light trap operated intermittently from April to August, 1959, in Gainesville, Florida. *Ips grandicollis, Monarthrum fasciatum, Orthotomicus caelatus, Xyleborus ferrugineus*, and *Platypus compositus* were collected in large numbers. *I. avulsus, I. calligraphus* and *Dendroctonus terebrans* were among the species collected less frequently.
ULTRAVIOLET LIGHT TRAP

310 Ostrom, C.E.
1955. **The tree improvement research program of the Southeastern forest experiment station.** Proc. Conf. on For. Tree Improvement 3:101-104.
Mentions that slash and longleaf pines at Lake City, Florida were being selected for resistance to the black turpentine beetle.
RESISTANCE, CONTROL

311 Outcalt, K.W.; Stubbs, J.
1979. **Insect attack and tree mortality in paraquat-treated stands at the Savannah river plant.** Pages 56-64 in Esser, M.H., ed. Sixth Annu. Lightwood Res. Conf. Proc.; 1979 January 17-18; Atlanta, Ga. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 151 p.
Updates earlier reports (Moore 1977, Stubbs 1978) of lightwood induction studies done in loblolly and slash pine stands at the Savannah River Plant in South Carolina. Bark beetle attacks and tree mortality increased as the concentration of paraquat solutions increased. Insecticides (BHC, chlorpyrifos, chlorpyrifos-methyl) reduced tree mortality, but were not cost effective due to the generally low mortality in these studies. There was no spread of bark beetle infestations from treated trees to adjacent untreated or less severely treated trees.
CHEMICAL CONTROL, LIGHTWOOD INDUCTION, PARAQUAT, BHC, DURSBAN, RELDAN

312 Overgaard, N.A.
1968. **Insects associated with the southern pine beetle in Texas, Louisiana, and Mississippi.** J. Econ. Entomol. 61:1197-1201. 1 tab, 3 figs, 2 refs.
Lists 42 families containing 84 species of insects reared from southern pine beetle-infested trees. The black turpentine beetle and the 3 southern *Ips* spp. were found in each of the three states and are listed as competitors of the southern pine beetle for the phloem food supply.
PARASITES, PREDATORS, ASSOCIATES

313 Overgaard, N.A.; Nachod, L.H.
1971. **Deodar weevil causes pine mortality in Louisiana.** J. Econ. Entomol. 64:1329-1330. 3 figs, 3 refs.
Reports *Ips avulsus, I. grandicollis*, and *I. calligraphus* colonizing loblolly pines already infested by *Pissodes nemorensis* (Germar).
ASSOCIATES

314 Overgaard, N.A.; Balmer, W.E.; Roberts, D.R.
1977. **Evaluation of insect infestations on paraquat-treated loblolly and slash pines.** Pages 12-18 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1977 January 18-19; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 193 p.
Most of the *Ips* spp. beetles and many of the *Dendroctonus terebrans* were found dead in paraquat-treated trees 5 months after treatment.

It could not be ascertained whether the 1% BHC aqueous basal spray or the paraquat treatment may have affected bark beetle brood survival. The true impact of bark beetles in these extensive tests could not be evaluated because there were no paraquat-treated trees not sprayed with insecticide.
CHEMICAL CONTROL, LIGHTWOOD INDUCTION, PARAQUAT, BHC

315 Packard, A.S.
1887. **Insects injurious to forest and shade trees.** U. S. Dep. Agric. Entomol. Comm. Bull. 7:175-176, 243.
Packard borrows the morphological description of what he calls *Hylurgus terebrans* (Olivier) from an earlier Harris treatise. Packard also quotes LeConte as having recognized morphological differences between northern/western specimens and southern specimens, these differences apparently representing *Dendroctonus terebrans* and *D. valens.*
TAXONOMY. MORPHOLOGY

316 Packard, A.S.
1890. **Insects injurious to forest and shade trees.** U. S. Dep. Agric., Fifth Rep. U. S. Entomol. Comm. 957 p. 40 plates.
A revised and enlarged edition of Packard's 1887 bulletin, this is a compendium of writings by earlier authors plus Packard's observations of 25 years. *Tomicus* [ = *Ips*] *calligraphus* is discussed on pp. 711-172. *T. cacographus* [ = *I. grandicollis*] on p. 713, and *Dendroctonus terebrans* [in part, *D. valens*] on pp. 721 and 858.
MORPHOLOGY, BEHAVIOR, BIOLOGY

317 Paine, T.D.; Birch, M.C.; Švihra, P.
1981. **Niche breadth and resource partitioning by four sympatric species of bark beetles (Coleoptera: Scolytidae).** Oecologia (Berl) 48:1-6. 3 tabs, 5 figs, 38 refs.
Presents indices of niche breadth, niche overlap, species diversity, and species evenness for 4 species of bark beetles colonizing 27 loblolly pines in east Texas [see also Birch et al. 1980 and Švihra et al. 1980]. *Ips calligraphus* colonized the midbole and was overlapped extensively by *D. frontalis* and *I. avulsus*. *I. avulsus* dominated colonization of the upper levels. *I. grandicollis* was relatively rare, coinhabiting the midbole with the other species while being the principal colonizer of branches.
SPECIES DIVERSITY, DISTRIBUTION, COMPETITION, NICHE BREADTH, NICHE OVERLAP

318 Payne, T.L.; Moeck, H.A.; Willson, C.D.; Coulson, R.N.; Humphreys, W.J.
1973. **Bark beetle olfaction - II. Antennal morphology of sixteen species of Scolytidae (Coleoptera).** Int. J. Insect Morphol. Embryol. 2:177-192. 1 tab, 30 figs, 17 refs.
The antennae of 16 species of Scolytidae, including *Dendroctonus terebrans*, *Ips avulsus*, *I. grandicollis*, and *I. calligraphus*, were studied by scanning electron microscopy. Each species was studied for the type, location, relative abundance, and range in size of the sensillae on its antenna. The authors speculate on the possible function of some of the sensillae.
MORPHOLOGY, PHYSIOLOGY, PHEROMONES, PHEROMONE RECEPTION, SENSILLAE, CHEMORECEPTORS, MECHANORECEPTORS

319 Payne, T.L.; Richerson, J.V.
1979. **Management implications of inhibitors for *Dendroctonus frontalis* (Coleoptera: Scolytidae).** Mitt. Schweiz Entomol. Ges. 52:323-331. 5 tabs, 1 fig, 22 refs.
The use of the inhibitors brevicomin and verbenone on selected loblolly pines in an expanding *Dendroctonus frontalis* infestation resulted in greater catches of *Ips avulsus* on the treated trees. Whereas only *D. frontalis* colonized the 3 to 9 m height on untreated trees, many *I. avulsus* colonized this height on the treated trees. This interaction between the 2 bark beetles precludes the use of only the 2 chemicals to protect individual uninfested trees when both species are present in an infestation. [These same and additional data are presented in Richerson and Payne 1979].
ANTIAGGREGATION PHEROMONES, BREVICOMIN, VERBENONE

320 Pierce, P.E.
1971. **The recovery of hail damaged pine timber: Some silvicultural and entomological considerations.** Fayetteville, AR: Univ. of Arkansas. vi + 80 p. 7 tabs, 18 figs, 15 refs. Thesis.
Bark beetles did not appear to be a significant factor in the low levels of tree mortality observed in the second and third growing seasons following a damaging hail storm. [See Walrod 1970 for first-year data.] Attempts to induce bark beetle infestations were successful only on trees with oleoresin exudation rates below 2 cm/hr and with diameters less than 15 cm. *Ips grandicollis* attacked 3 of the 4 trees which died, *I. calligraphus* attacked the other. *Dendroctonus terebrans* attacks occurred on 4 *Ips*-baited trees of large diameter (over 15 cm dbh) and high O.E.R. (4-8 cm/hr); none of the attacked trees died.
PHYSICAL FACTORS, HAIL, TREE SUSCEPTIBILITY, STRESS, OLEORESIN EXUDATION RATE

321 Plumb, G.H.; Decaprio, A.
1940. **Bark beetle damage to pine plantation.** Conn. Agric. Exp. Stn. (New Haven) Bull. 434:315-317. 2 figs.
Reports infestations of *Ips grandicollis*, *I. calligraphus*, and *I. pini* in plantations of *Pinus strobus* and *P. resinosa* in Connecticut during the fall of 1939. [R. B. Friend, the Connecticut state entomologist, is sometimes cited as the author of this report.]
OUTBREAK

322 Polivka, J.B.
1938. **Forest Insect Survey. In: Progress of Agricultural Research in Ohio 1936-1937.** Ohio Agric. Exp. Stn. Bull. 592. pp. 129-130.
Reports the occurrence of *Ips calligraphus*, *I. grandicollis*, and *Dendroctonus terebrans* in Ohio during 1936 and 1937. The author notes that when pine slash is not readily available as breeding material the *Ips* beetles, particularly *I. calligraphus*, emerge from the slash and attack pines of low vigor. Many pines were attacked by the black turpentine beetle but, when pitch flow was copius, the beetles were pitched out.
OUTBREAK

323 Price, T.S.; Godbee, J.F.
1978. **Black turpentine beetle in Georgia.** Macon, Georgia: Georgia Forestry Commission. 3 p. 5 figs.
A colorful extension leaflet that describes and illustrates the life history of the black turpentine beetle and its control on shade trees and in naval stores operations.
BIOLOGY, CHEMICAL CONTROL

324 Provancher, L.
1877. **Petite faune entomologique du Canada. Volume 1— Les Coleopteres.** Quebec: C. Darveau Press. 786 p.
Contains brief descriptions of the external morphology of *Ips calligraphus* (p. 570) and *Dendroctonus valens* (pp. 572-573), mistakenly identified as *D. terebrans*.
MORPHOLOGY

325 Ragenovich, I.R.; Coster, J.E.
1974. **Evaluation of some carbamate and phosphate insecticides against southern pine beetle and *Ips* bark beetles.** J. Econ. Entomol. 67:763-765. 2 tabs, 2 figs, 5 refs.

Lindane, propoxur, and carbaryl were effective in preventing *Ips grandicollis* and *I. calligraphus* attacks on loblolly pine logs for at least 6 weeks. Diazinon and phosmet were effective for only 4 weeks, and acephate was ineffective.
CHEMICAL CONTROL, PHOSMET, DIAZINON, LINDANE, PROPOXUR, CARBARYL, ACEPHATE

326 Renwick, J.A.A.; Vité, J.P.
1972. **Pheromones and host volatiles that govern aggregation of the six-spined engraver beetle, *Ips calligraphus*.** J. Insect Physiol. 18:1215-1219. 3 tabs, 6 refs.
This paper proposes the now accepted trivial names "ipsenol" and "ipsdienol" for the compounds 2-methyl-6-methylene-7-octen-4-ol and 2-methyl-6-methylene-2,7-octadien-4-ol. The combination of ipsdienol and cis-verbenol was highly attractive to *Ips calligraphus*; the addition of host volatiles increased the response to this combination.
PHEROMONES, SEMIOCHEMICALS, IPSENOL, IPSDIENOL, VERBENOL

327 Richerson, J.V.; Payne, T.L.
1979. **Effects of bark beetle inhibitors on landing and attack behavior of the southern pine beetle and beetle associates.** Environ. Entomol. 8:360-364. 5 tabs, 18 refs.
More *Ips avulsus* were caught in landing traps on loblolly pines treated with brevicomin isomers and verbenone than on untreated trees. There were also corresponding increases in the densities of *Ips* egg galleries. Thus, although several treatments may reduce *Dendroctonus frontalis* attacks and brood production, they may not reduce tree mortality where *Ips* beetles are present.
ANTIAGGREGATION PHEROMONES, BREVICOMIN, VERBENONE

328 Richeson, J.S.
1969. **Fatty acid composition of *Ips calligraphus* (Germar) during postembryonic development.** Gainesville, FL: Univ. Fla. v + 57 p. 9 tabs, 8 figs, 135 refs. M.S. thesis.
See Richeson et al. 1970, 1971.
PHYSIOLOGY, GROWTH, FATTY ACIDS, DIET, REARING

329 Richeson, J.S.; Wilkinson, R.C.; Nation, J.L.
1970. **Development of *Ips calligraphus* on foliage-based diets.** J. Econ. Entomol. 63:1797-1799. 1 tab, 1 fig, 14 refs.
Rearing media containing previous year's slash pine foliage provided greater survivorship and shorter developmental times than media containing current year's foliage. Thus, pine foliage may be substituted for phloem in some semiartificial media.
REARING, DIET

330 Richeson, J.S.; Nation, J.L.; Wilkinson, R.C.
1971. **Fatty acid composition in *Ips calligraphus* (Coleoptera: Scolytidae) during postembryonic development.** Ann. Entomol. Soc. Am. 64:251-254. 1 tab, 20 refs.
Presents the relative quantities of fatty acids present at various developmental stages of *Ips calligraphus* reared on a phloem-based artificial medium.
PHYSIOLOGY, GROWTH, FATTY ACIDS

331 Rimes, G.D.
1959. **The bark beetle in west Australian pine forests.** J. Dep. Agric. W. Aust. 8(3):353-355; 1959. 2 figs, 6 refs.
Reports that *Ips grandicollis* has been infesting logs and logging slash in western Australia for about 10 years. Prompt removal of logs from the cutting area and spraying log decks with 0.3 per cent water emulsion of lindane are recommended for preventing beetle infestation and log degrade.
LIFE HISTORY, DAMAGE, CHEMICAL CONTROL, LINDANE

332 Roberts, D.R.
1978. **Southwide induction of lightwood with paraquat — Second LRCC standard experiment.** Pages 110-115 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.
Contains a brief description of insect problems and research in the lightwood indiction research program. [See Overgaard et al. (1977) for more details of the entomological portion of this southwide study.]
DAMAGE, LIGHTWOOD INDUCTION, PARAQUAT

333 Robertson, R.L.; Whitfield, F.E.
1968. **The turpentine beetle in North Carolina.** North Carolina State Univ. Ext. Folder 273, 8 p. Raleigh, NC.
Describes the life history of the black turpentine beetle with recommendations for preventing attacks. Has particularly good instructions for preparing BHC and lindane fuel oil solutions and lindane water emulsions. Also mentions the prevalence of red turpentine beetles, *D. valens*, in the mountains of western North Carolina.
LIFE HISTORY, DAMAGE, CHEMICAL CONTROL, APPLIED CONTROL, ATTACK

334 Robillard, J.
1971. **A new species of *Digamasellus* (Acarina: Digamasellidae) from Louisiana.** Can. Entomol. 103:1763-1774. 26 figs, 5 refs.
Taxonomic description for *Digamasellus quadritorus* found associated with *Ips avulsus* and *I. grandicollis* infesting slash pines.
MITES

335 Rohlfs, W.M.; Hyche, L.L.
1981. **Colydiidae associated with *Ips* in southern pines: Relative abundance and time of arrival of adults at pines under attack by *Ips* spp.** J. Econ. Entomol. 74(4):458-460. 1 fig, 6 refs.
*Lasconotus referendarius* Zimmermann was the most numerous of six species of cylindrical bark beetles trapped on *Ips*-infested trees and it tended to arrive ca. two weeks after the peak *Ips* arrival. *L. pusillus* LeConte was nearly as abundant as the first species and it arrived concurrently with the majority of the *Ips*. *Colydium nigripenne* LeConte, *Pycnomerus sulcicollis* LeConte, *Aulonium tuberculatum* LeConte, and *A. ferrugineum* Zimmermann were the other species collected.
ASSOCIATES

336 Rose, W.F.; Billings, R.F.; Vité, J.P.
1981. **Southern pine bark beetles: Evaluation of non-sticky pheromone trap designs for survey and research.** Southwest. Entomol. 6:1-9. 1 fig, 2 tabs, 20 refs.
Presents spring and summer data on the capture of the 3 *Ips* species and *Thanasimus dubius* in 6 kinds of non-sticky, pheromone traps. A funnel and water-filled jar suspended beneath a polyethylene sheet was judged the most practical and efficient design.
PHEROMONE TRAPS

337 Rumbold, C.T.
1931. **Two blue-staining fungi associated with bark-beetle infestation of pines.** J. Agric. Res. 43(10):847-873. 3 tabs, 8 figs, 16 refs.
Contains the original taxonomic description for the blue-stain fungus *Ceratostomella (Ceratocystis) ips*. Included are descriptions of the fungus in stained wood and in laboratory cultures. The fungus was

recovered in association with *Ips calligraphus* and *I. grandicollis* and also from pines infested by *I. avulsus* and *I. pini*. Briefly mentions the isolation of *Leptographium lundbergii* from a tree infested by *I. calligraphus*.
FUNGI

338 Saunders, W.
1880. **Annual address of the president of the Entomological Society of Ontario.** Annu. Rep. Entomol. Soc. Ont. 10:5.
Briefly describes the larvae of *Hylurgus terebrans* feeding in the inner bark of pine, but the description of the quarter-inch long, chestnut red-colored adults is an obvious reference to *Dendroctonus valens*, not *D. terebrans*.
ATTACK, DAMAGE, LARVAL FEEDING

339 Saunders, W.
1883. **Insects injurious to the white pine.** Annu. Rep. Entomol. Soc. Ont. 14:55.
Contains a brief description of *Dendroctonus valens*, mistakenly reported as *Hylurgus (Dendroctonus) terebrans*, as a pest of white pine.
ATTACK, DAMAGE, LARVAL FEEDING

340 Savely, H.E., Jr.
1939. **Ecological relations of certain animals in dead pine and oak logs.** Ecol. Monogr. 9:321-385. 7 tabs, 8 figs, 83 refs.
Documents insect succession in pine and oak logs near Durham, NC and relates their occurrence to microclimatic temperature and moisture conditions. *Ips calligraphus, I. grandicollis*, and *Dendroctonus terebrans* are listed among the 55 species of beetles found in first-year pine logs.
MICROCLIMATE, TEMPERATURE, MOISTURE, INSECT SUCCESSION

341 Say, Thomas
1826. **Descriptions of new species of Coleopterous insects inhabiting the United States.** J. Acad. Nat. Sci. Philadelphia 5:237-283.
Pages 255-257 contain the original taxonomic descriptions for 5 species of *Bostrichus*. One species, *B. exesus*, was recognized as a junior synonym of *Tomicus calligraphus* Germar (1824) by J.L. LeConte in 1876.
TAXONOMY

342 Schenk, J.A.; Benjamin, D.M.
1964. **A tentative classification of jack pine susceptible to bark beetle attack in central Wisconsin.** J. For. 62:570-574. 4 tabs, 2 figs, 19 refs.
Proposes 5 susceptibility classes based on a crown index which is the product of the live crown ratio and the radial crown fullness. It is speculated that the removal of the most susceptible trees during scheduled thinnings would reduce bark beetle breeding material and reduce losses during outbreaks of *Ips pini* and *I. grandicollis*.
CULTURAL CONTROL

343 Schmitt, J.J.
1980. **The biology, life history and description of immatures of *Scoloposcelis mississippensis* Drake and Harris and *Lyctocoris elongatus* (Reuter), predators of pine bark beetles.** Baton Rouge, LA.: Louisiana State Univ. viii + 68 p. 8 tabs, 11 figs. M. Sci. Thesis.
See Schmitt and Goyer 1983.
PREDATORS

344 Schmitt, J.J.; Goyer, R.A.
1983. **Consumption rates and predatory habits of *Scoloposcelis missippensis* and *Lyctocoris elongatus* (Hemiptera: Anthocoridae) on pine bark beetles.** Environ. Entomol. 12:363-367.
Presents information on the developmental times, longevity, and fecundity of two anthocorids. *Ips grandicollis* and *Dendroctonus frontalis* were used as prey for determining their bark beetle consumption rates.
PREDATORS

345 Schwarz, E.A.
1878. **Coleoptera of Florida.** Proc. Am. Philos. Soc. 17:353-472.
The 3 *Ips* species were collected at several localities in Florida during the author's visits in 1875 and 1876. *Dendroctonus terebrans* was "rare" during the author's stay in the Tampa area in the spring of 1876.
DISTRIBUTION, INSECT LISTS

346 Schwarz, E.A.
1886. **Remarks on North American Scolytids.** Entomol. Am. 2:40-42, 44, 54-56.
Briefly mentions problems in separating some of the then-recognized species of *Dendroctonus* and stresses the need for accurate life-history data before drawing final conclusions on species differences.
TAXONOMY, MORPHOLOGY

347 Schwarz, E.A.
1888. **[Scolytids found on *Pinus inops* in the vicinity of Washington.].** Proc. Entomol. Soc. Wash. 1:80.
*Ips calligraphus, I. grandicollis*, and *Dendroctonus terebrans* are 3 of the 19 Scolytid species found by the author on *Pinus virginiana*.
HOST TREES

348 Smiley, R.L.; Moser, J.C.
1968. **New species of mites from pine (Acarina: Tarsocheliidae, Eupalopsellidae, Caligonellidae, Cryptognathidae, Raphignathidae, and Neophyllobiidae).** Proc. Entomol. Soc. Wash. 70:307-317. 14 figs, 6 refs.
Two new genera and six new species of mites are described. Four species were found under loose bark of loblolly pines infested by southern *Ips* species.
MITES

349 Smiley, R.L.; Moser, J.C.
1970. **Three Cheyletids found with pine bark beetles.** Proc. Entomol. Soc. Wash. 72:229-236. 20 figs, 3 refs.
*Acaracheyla impolita* was found once in the galleries of *Dendroctonus terebrans* and frequently in the boring dust of the *Ips* species. *A. virginiensis* was collected from the boring dust of *Ips calligraphus* and females were phoretic on *I. avulsus* and *I. grandicollis*.
MITES

350 Smiley, R.L.; Moser, J.C.
1974. **New Tarsonemids associated with bark beetles (Acarina: Tarsonemidae).** Ann. Entomol. Soc. Am. 67:639-665. 69 figs, 15 refs.
Taxonomic descriptions and illustrations for a number of Tarsonemid mites are presented. One species was collected from *Ips grandicollis* and many species are associated with *Dendroctonus frontalis*.
MITES

351 Smiley, R.L.; Moser, J.C.
1975. **Redescription of *Eutogenes vicinus* Summers and Price, a predatory polymorphic, Cheyletid mite, with descriptions of males and immature stages (Acarina: Cheyletidae).** Proc.

Entomol. Soc. Wash. 77:405-418. 49 figs, 5 refs.
The polymorphic mite *Eutogenes vicinus*, an associate of *Dendroctonus frontalis* and *Ips avulsus*, is redescribed.
MITES

352 Smiley, R.L.; Moser, J.C.
1976. **Two new phoretomorphic *Siteroptes* from galleries of the southern pine beetle (Acarina: Pyemotidae).** Beitr. Entomol. (Berlin) 26:307-322. 37 figs, 10 refs. [In English with German and Russian summaries.]
The mites *Siteroptes fusarii* and *S. trichoderma* apparently feed on certain fungi in pines infested by bark beetles.
MITES

353 Smith, J.B.
1900 [Frequently cited as 1899.] **Insects of New Jersey.** New Jersey Bd. Agric., Suppl. 27th Ann. Rep., pp. 363-364.
Lists (p. 363) *Tomicus* [=*Ips*] *calligraphus* and *T. cacographus* [=*I. grandicollis*] as occurring in pine and spruce trees in New Jersey. Mentions (p. 364) that *Dendroctonus terebrans* "mines in green bark and turpentine on pine."
DISTRIBUTION

354 Smith, J.B.
1901. **[Scolytids in decaying pines in New Jersey].** Entomol. News 12:92-93
Reports the gallery patterns and distributions of Scolytids in decaying pines in Lahaway, New Jersey. Although Smith was already familiar with *D. terebrans* (Smith 1900), some authors (e.g., Hopkins 1909a, p. 150) report that the "new species of Dendroctonus" mentioned in this paper is nonetheless a reference to *D. terebrans. Tomicus* [=*Ips*] *calligraphus* and *T. cacographus* [=*I. grandicollis*] are mentioned briefly.
ATTACK, GALLERY PATTERN, DISTRIBUTION

355 Smith, R.H.
1954. **Studies in the control of the black turpentine beetle in southern pine.** (Abst.) Assoc. South. Agric. Workers Proc. 51:100.
Ethylene dibromide, alone or in combination with BHC, effectively killed black turpentine beetle broods under the bark of fresh cut stumps. BHC in no. 2 fuel oil was the best chemical for preventing *D. terebrans* attacks on fresh cut stumps. Ammonium bifluoride applied to axe-cut frills rendered stumps unsuitable for black turpentine beetle attack and breeding.
CHEMICAL CONTROL, BHC, DDT, ALDRIN, CHLORDANE, ETHYLENE DIBROMIDE, ORTHODICHLOROBENZENE, TRICHLOROBENZENE, AMMONIUM BIFLORIDE

356 Smith, R.H.
1954. **Benzene hexachloride controls black turpentine beetle.** Southern Lumberman 189(2369):155-157.
Some of the earliest of numerous field tests, conducted in north Florida from 1953 to 1955, are described. Also included is a thorough and concise description of the life history and tree-attack behavior of the black turpentine beetle. The author defines his use of "preventive" and "remedial" control.
LIFE HISTORY, CHEMICAL CONTROL, BEHAVIOR, ATTACK

357 Smith, R.H.
1955. **Control of the black turpentine beetle with a benzene hexachloride (BHC) post-attack spray.** Assoc. South. Agric. Workers Proc. 52:99-100.
Describes a procedure for spraying black turpentine beetle-infested slash pines with 1% BHC in diesel oil that controlled existing attacks while preventing subsequent attacks. Control was particularly effective in heavily infested naval stores stands.
CHEMICAL CONTROL, APPLIED CONTROL, TREE MORTALITY, BHC, NAVAL STORES

358 Smith, R.H.
1955. **A control for the black turpentine beetle in south Georgia and north Florida.** U. S. For. Serv. Southeast. For. Exp. Stn. Res. Note 76. 2 p.
A concise, thorough description of the application of BHC-fuel oil solutions in infested naval stores stands and alternative recommendations for insecticide applications prior to and following the harvest of infested trees.
BEHAVIOR, ATTACK, CHEMICAL CONTROL, APPLIED CONTROL

359 Smith, R.H.
1956. **Death of a pine.** For. Farmer 15(12):7. 6 figs.
A concise, pictorial article on the rate of deterioration of slash pines in Florida following successful black turpentine beetle attacks.
TREE MORTALITY, TREE DETERIORATION

360 Smith, R.H.; Lee, R.E.
1957. **Black turpentine beetle.** U. S. For. Serv. For. Pest Leafl. 12. 7 p. 7 figs, 2 refs.
A thorough summary of the range, hosts, life history, and behavior of the black turpentine beetle. Natural control is discussed briefly. Chemical control with a 1% BHC diesel oil, or no. 2 fuel oil solution is emphasized.
LIFE HISTORY, BEHAVIOR, CHEMICAL CONTROL, BIOLOGICAL CONTROL, HOST TREES, GEOGRAPHIC DISTRIBUTION

361 Smith, R.H.
1957. **Habits of attack by the black turpentine beetle on slash and longleaf pine in north Florida.** J. Econ. Entomol. 50:241-244.
Smith's intensive study of beetle attack behavior provided the basis for the control recommendation that insecticides need only to be applied to the basal 18 inches of attacked trees during the first month that attacks are initiated to prevent additional attacks on the trunk. Smith speculated that attacks made above 18 inches were either dependent on the lower attacks or made by beetles which first contacted the tree in the basal 18 inches.
BEHAVIOR, ATTACK

362 Smith, R.H.
1958. **Control of the turpentine beetle in naval stores stands by spraying attacked trees with benzene hexachloride.** J. For. 56:190-194. 2 tabs, 3 figs, 4 refs.
Describes insecticide application procedures for black turpentine beetle control in naval stores stands and in any forest management situation where salvage and stump spraying is deemed unfeasible. This is one of the best documented articles on the insecticidal control of the black turpentine beetle with control objectives and results clearly described.
CHEMICAL CONTROL, APPLIED CONTROL, TREE MORTALITY, DAMAGE

363 Smith, R.H.
1963. **Preferential attack by *Dendroctonus terebrans* on *Pinus elliottii*.** J. Econ. Entomol. 56(6):817-819. 1 tab, 8 refs.
Demonstrates that black turpentine beetles are strongly attracted to previously attacked trees and that attacks on a given tree may occur over a 5- to 7-month period.
BEHAVIOR, ATTACK, AGGREGATION

364 Smith, R.H.; Kowal, R.J.
1968. **Attack of the black turpentine beetle on roots of slash pine.** J. Econ. Entomol. 61:1430-1432. 1 tab, 2 figs, 2 refs.
Describes the nature and location of black turpentine beetle attacks

on roots and discusses the implications of these findings to applied control.
BROOD MATERIAL, APPLIED CONTROL, BEHAVIOR, ATTACK, DAMAGE

365 Smith, R.H.; Lee, R.E.
1972. **Black turpentine beetle.** U. S. For. Serv. For. Pest Leafl. 12. 8 p. 7 figs, 2 refs.
A slight revision of the 1957 forest pest leaflet.
BIOLOGY, LIFE HISTORY, BEHAVIOR, ATTACK, HOST TREES, DAMAGE, CHEMICAL CONTROL, BIOLOGICAL CONTROL

366 Smith, R.H.
1976. **Effectiveness of lindane against bark beetles and wood borers.** Pages 11-15 in T.W. Koerber (ed.), Lindane in Forestry - A Continuing Controversy. U. S. For. Serv. Gen. Tech. Rep. PSW-14. 30 p. 29 refs.
Briefly summarizes results of several tests with BHC fuel oil solutions and water emulsions to prevent and control the black turpentine beetle. Tests were conducted in Florida, Mississippi, and Louisiana from 1952-1955.
CHEMICAL CONTROL, LINDANE

367 Smith, V.K., Jr.
1959. **Treating stored wood— decay in pulpwood inventories can be reduced.** Pulpwood Production 7(2):10,12.
Dipping pulpwood in a combination insecticide and fungicide solution can substantially reduce *Ips* infestation and losses in specific gravity.
DAMAGE, CHEMICAL CONTROL, PHYSICAL CONTROL, PENTACHLOROPHENOL, BHC, SODIUM PENTACHLOROPHENATE

368 Smith, V.K., Jr.
1965. **Protecting logs, bolts, and chips from insects.** Proc. 14th Annu. For. Symp., Louisiana State Univ., pp.125-129. 6 refs.
Briefly summarizes methods for protecting logs and bolts from insect attack and infestation.
CHEMICAL CONTROL, PHYSICAL CONTROL

369 Snow, F.H.
1877. **List of Coleoptera collected in Colorado in June, July and August, 1876, by the Kansas University Scientific Expedition.** Trans. Kans. Acad. Sci. 5:16-21.
Reports the collection of 8 specimens of "*Dendroctonus terebrans* Lec." at Colorado Springs. [The beetles were probably *Dendroctonus valens*.]
DISTRIBUTION, INSECT LISTS

370 Snow, F.H.
1881. **List of Coleoptera collected in Santa Fe Canon, New Mexico, by the Kansas University Expedition for 1880.** Trans. Kans. Acad. Sci. 7:67-71.
Lists "*Dendroctonus terebrans* Oliv." as one of 237 species of Coleoptera collected near the city of Santa Fe in August of 1880. [The correct identification of the species is probasbly *D. valens*.]
DISTRIBUTION, INSECT LISTS

371 Snow, F.H.
1883. **Lists of Lepidoptera and Coleoptera collected in New Mexico by the Kansas University Scientific Expiditions of 1881 and 1882.** Trans. Kans. Acad. Sci. 8:35-45.
Reports the collection of "*Dendroctonus terebrans* Oliv." near Las Vegas hot springs in the summer of 1882. [The correct identification of this species is probably *D. valens*.]
DISTRIBUTION, INSECT LISTS

372 Snow, F.H.
1906. **Some results of the University of Kansas Entomological Expeditions to Arizona in 1904 and 1905.** Trans. Kans. Acad. Sci. 20(Part 1):155-181.
Reports the collection of "*Dendroctonus terebrans* Oliv." southwest of Flagstaff, Arizona in the summer of 1904. [The correct identification of this species is probably *D. valens*.]
DISTRIBUTION, INSECT LISTS

373 Snow, F.H.
1907. **List of Coleoptera collected in New Mexico by the entomological expeditions of the University of Kansas.** Trans. Kans. Acad. Sci. 20(Part 2):165-189.
This paper lists the combined results of six expeditions to New Mexico. Of the 20 species of Scolytidae reported, "*Dendroctonus terebrans* Oliv." was collected in the vicinities of Santa Fe and Gallinas Canyons. [The correct identification of this species is probably *D. valens*.]
DISTRIBUTION, INSECT LISTS

374 Speers, C.F.
1971. ***Ips* bark beetles in the South.** U. S. For. Serv. For. Pest Leafl. 129. 7 p. 5 figs, 5 refs.
Describes the signs of attack, identification, life history, and natural, indirect and direct controls for the 3 *Ips* species in the southern USA.
LIFE HISTORY, CHEMICAL CONTROL, CULTURAL CONTROL, PHYSICAL CONTROL

375 St. George, R.A.
1930. **Drought-affected and injured trees attractive to bark beetles.** J. Econ. Entomol. 23(5):825-828.
An anecdotal account of the author's observations that bark beetle problems are often associated with moisture stress, wind throw, and lightning strikes. Included is an account of *Ips calligraphus* and *I. grandicollis* infesting Massachusetts white pines located in a normally moist bottomland. [The author does not mention any *Ips* species in the examples of the southern pine beetle infesting windthrown and lightning-struck pines in North Carolina.]
STRESS, DROUGHT, LIGHTNING

376 Sterling, W.L.; Jones, D.; Dean, D.A.
1979. **Failure of the red imported fire ant to reduce entomophagous insect and spider abundance in a cotton agroecosystem.** Environ. Entomol. 8:976-981. 4 tabs, 39 refs.
Incidentally mentions red imported fire ant, *Solenopsis invicta* Buren, predation on *Ips avulsus*.
PREDATORS

377 Stewart, K.F.
1965. **Tests show seven-eleven to be effective.** Naval Stores Review 75(2):8-9,18.
This report parallels a scientific article by Bennett (1965) in the Journal of Economic Entomology in which a bark-penetrating wetting agent called "seven-eleven" was found to greatly enhance the preventative control action of BHC water emulsions against the black turpentine beetle.
CHEMICAL CONTROL

378 Storey, T.G.; Merkel, E.P.
1960. **Mortality in a longleaf-slash pine stand following a winter wildfire.** J. For. 58:206-210. 4 tabs, 3 figs, 4 refs.
Tree mortality was related to the amount of crown consumed by the fire and the height of bark char on the stem. An attempt to eliminate bark beetles as a mortality agent by spraying with BHC failed because beetles had infested some trees before spraying and most trees were not completely covered.
TREE MORTALITY, FIRE

379 Stubbs, J.

1978. **Large scale field testing of paraquat application techniques.** Pages 116-123 in Esser, M.H., ed. Proc. Annu. Meet. Lightwood Res. Coord. Council; 1978 January 10-11; Atlantic Beach, FL. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 211 p.

Presents data on insect attacks and tree mortality, oleoresin yields, and costs of treatments for several lightwood induction studies. One study was destroyed by too intense paraquat treatment and subsequent *Ips* attacks.

LIGHTWOOD INDUCTION, PARAQUAT, DAMAGE

380 Švihra, P.; Paine, T.D.; Birch, M.C.

1980. **Interspecific olfactory communications in southern pine beetles.** Naturwiss. 67:518-519. 1 fig, 15 refs.

*Dendroctonus frontalis* was the first species to attack 23 of 27 *Pinus taeda* sampled over a 12-month period in East Texas. *Ips avulsus* and *I. calligraphus* colonized the trunk shortly afterwards, while *I. grandicollis* arrived later and infested branches more frequently than the trunk. Experiments with artificially-infested bolts determined the enhancement or interruption of attraction when two species were confined together.

PHEROMONES, KAIROMONES, ATTACK

381 Švihra, P.

1982. **Influence of opposite sex on attraction produced by pioneer sex of four bark beetle species cohabiting pine in the southern United States.** J. Chem. Ecol. 8:373-378. 4 tabs, 14 refs.

The presence of the responding sex along with the pioneering sex in newly infested bolts significantly reduced the intraspecific responses of *Ips calligraphus* and *I. grandicollis*, but not *I. avulsus* and *Dendroctonus frontalis*. The cross-attraction of *I. avulsus* females to *I. calligraphus* was reduced by the presence of *I. calligraphus* females.

AGGREGATION PHEROMONES, MATING, ATTRACTION

382 Swaine, J.M.

1909. **Catalogue of the described Scolytidae of America, north of Mexico.** N.Y. State Mus. Bull. 134:76-159, 165-194 (plates 3-17).

Provides nearly complete references to the pre-1907 literature for 191 species of North American Scolytidae and lists their food plants and geographic distributions. A number of nomenclatural changes are proposed including the use of *Ips* DeGeer rather than *Tomicus* Latreille for *I. avulsus*. The 12 *Dendroctonus* species and 21 *Ips* species are catalogued on pages 95-100 and 119-126, respectively.

BIBLIOGRAPHY, TAXONOMY

383 Swaine, J.M.

1913. **Notes on some forest insects of 1912.** Ann. Report Entomol. Soc. Ontario, Toronto, 1913, pp. 87-91.

Briefly mentions that *Ips calligraphus* and other bark beetles were abundant in logging slash in Algonquin Park, Ontario, during 1912 and warns that the standing trees will be subject to attack when the cutting ceases.

OUTBREAK

384 Swaine, J.M.

1916. **New species of the family Ipidae (Coleoptera). Part III.** Can. Entomol. 48(6):181-192.

Describes *Ips chagnoni* from *Picea canadensis* and *Pinus strobus* in Ontario, Quebec, and New York. [Synonymized with *I. grandicollis* by Hopping (1965a).]

TAXONOMY

385 Swaine, J.M.

1918. **Canadian bark-beetles, part 2: A preliminary classification, with an account of the habits and means of control.** Can. Dep. Agric. Entomol. Branch Tech. Bull. 14. 143 p.

The first sections of this bulletin discuss the habits, injuries, means of control, and adult morphology of bark beetles. The remainder consists of keys to and descriptions of Canadian bark beetles with notes on their host trees and geographic distribution. *Ips calligraphus, I. grandicollis*, and *I. chagnoni* Swaine 1916 [ = *I. grandicollis*] are discussed on pages 112-113. *Dendroctonus terebrans* and *Ips avulsus* are also included in the keys although neither species occurs in Canada.

TAXONOMY, MORPHOLOGY, LIFE HISTORY, DAMAGE, APPLIED CONTROL, FIRE

386 Swaine, J.M.

1924. **The allies of *Ips confusus* Lec. in western America. Family Ipidae, Coleoptera.** Can. Entomol. 56:69-72.

This is the original taxonomic description for *Ips cloudcrofti*, later synonymized with *Ips cribricollis* (Eichhoff) and *Ips grandicollis* (Eichhoff) [see S. L. Wood 1955, 1977].

TAXONOMY

387 Swaine, J.M.

1925. **New species of Ipidae (Coleoptera).** Can. Entomol. 57:192-197.

Describes 9 new species of *Pityophthorus* plus 2 new species of *Ips*, *I. chamberlini* from *Pseudotsuda taxifolia* in Oregon and *I. ponderosae* from *Pinus ponderosa* in Arizona. [Lanier (1972) considers *ponderosae* to be a subspecies of *I. calligraphus*, but S. L. Wood (1982) considers it to be a junior synonym.]

TAXONOMY

388 Swaine, J.M.

1925. **The factors determining the distribution of North American bark-beetles.** Can. Entomol. 57(11):261-266.

*Dendroctonus terebrans* is mentioned as occurring on loblolly, longleaf, and other southern pines and its distribution is limited by its preference for a warmer climate rather than by a choice of host trees. *D. terebrans* also breeds in eastern white pine and red spruce in the transitional zone in Virginia and West Virginia.

HOST TREES, GEOGRAPHIC DISTRIBUTION, CLIMATIC FACTORS

389 Taylor, A.R.

1974. **Ecological aspects of lightning in forests.** Proc. Annu. Tall Timbers Fire Ecol. Conf. 13:455-482, Tallahassee, Florida.

Reviews the direct and indirect effects of lightning in forests. Includes a discussion of lightning as a precursor to scolytid beetle attack.

PHYSICAL FACTORS, LIGHTNING

390 Thatcher, R.C.

1960. **Bark beetles affecting southern pines: A review of current knowledge.** U. S. For. Serv. South. For. Exp. Stn. Occasional Pap. 180. 25 p., 125 refs.

A comprehensive review of scientific literature and U. S. Forest Service reports in the subject areas of environmental influences, biotic control factors, and chemical control. Compares the biological and behavioral characteristics of the two *Dendroctonus* species and three *Ips* species. Recorded outbreaks of the various species are tabulated through 1958. Concludes with a concise discussion of needed research.

REVIEW, PHYSICAL FACTORS, BIOLOGY, PARASITES, PREDATORS, CHEMICAL CONTROL, TREE PHYSIOLOGY, STAND CONDITIONS

391 Thatcher, R.C.

1967. **Winter brood development of the southern pine beetle in southeast Texas.** J. Econ. Entomol. 60:599-600. 1 fig, 3 refs.

Mentions that *Dendroctonus terebrans, Ips grandicollis* and *I. calligraphus* were found in the basal sections of trees being observed for winter development of *D. frontalis* broods.

DISTRIBUTION

392 Thomas, Cyrus

1876. **Sixth report of the state entomologist on the noxious and beneficial insects of the state of Illinois.** First Biennial Rep. Part I:146.

The author's description of *Hylurgus terebrans* adults as reddish-colored and their occurrence in Illinois make this an obvious reference to *Dendroctonus valens* LeConte, not *D. terebrans* (Olivier).

TAXONOMY, DAMAGE

393 Thomas, J.B.

1957. **The use of larval anatomy in the study of bark beetles (Coleoptera: Scolytidae).** Can. Entomol. Suppl. 5. 45 p.

This is a major taxonomic paper on the anatomical characters useful in identifying genera of Scolytid larvae. The research included the examination of larvae accurately associated with known adults of 15 genera and 30 species. *Ips calligraphus* and *I. grandicollis* [as *I. chagnoni* Swaine] were two of the five *Ips* species examined.

TAXONOMY, MORPHOLOGY, ANATOMY, LARVAE

394 Thomas, J.B.

1965. **The immature stages of Scolytidae: The genus *Dendroctonus* Erichson.** Can. Entomol. 97(4):374-400.

Describes and illustrates the external anatomy for the larvae and pupae of most species of *Dendroctonus*. Larvae of *D. terebrans* and *D. valens* are readily separated from the other species by the presence of armed, fused tergal plates on the 8th and 9th abdominal segments; the differences between the two are of degree only, there being no anatomical variations. Pupae of these two species are indistinguishable from one another, but are separated from other species by the conspicuously roughened setae occurring over most of the body.

TAXONOMY, MORPHOLOGY, LARVAE, PUPAE

395 Thomas, J.B.

1967. **A comparative study of gastric caeca in adult and larval stages of bark beetles (Coleoptera: Scolytidae).** Proc. Entomol. Soc. Ont. 97:71-90.

Describes and illustrates the gastric caeca for larvae and adults of *Dendroctonus terebrans, Ips avulsus, I. grandicollis, I. calligraphus*, and 79 other species of bark beetles. Discusses the application of these characters to taxonomic problems in the family Scolytidae.

TAXONOMY, MORPHOLOGY

396 Turnbow, R.H., Jr.; Franklin, R.T.

1981. ***Platysoma (Cylistix) cylindrica* Payk.: Response to ipsenol.** J. Ga. Entomol. Soc. 16(2):171-175. 1 tab, 10 refs..

This predatory Histerid beetle responded to traps baited with ipsenol, but not to traps baited with ipsdienol. The kairomonal use of ipsenol in the predator-prey relationship is discussed.

PREDATORS, KAIROMONES, IPSENOL, IPSDIENOL

397 Turnbow, R.H., Jr.; Franklin, R.T.

1980. **Flight activity by Scolytidae in the northeast Georgia Piedmont (Coleoptera).** J. Ga. Entomol. Soc. 15(1):26-37. 2 tabs, 13 refs.

Presents data on the spatial and seasonal capture of 44 Scolytid species in flight traps along a transect from a hardwood bottomland across a pine ridge. Single adults of *Dendroctonus terebrans* were captured in the months of April, May, and June, 1976. *Ips avulsus* and *I. grandicollis* were collected in low numbers from March through August.

SEASONAL FLIGHT, DISTRIBUTION

398 Ulke, Henry

1903. **A list of the beetles of the District of Columbia.** Proc. U.S. National Museum 25(1275). 57 p.

Lists *Dendroctonus terebrans, Tomicus* [*Ips*] *calligraphus, T. cacographus* [*I. grandicollis*], and *T. avulsus* among the 57 species of Scolytidae occurring in the District of Columbia.

DISTRIBUTION

399 U. S. Dep. Agric., Bureau of Entomology, Division of Forest Insect investigations.

1927. **The relation of insects to slash disposal.** U. S. Dep. Agric. Dep. Circ. 411. 12 p.

Reviews the role of pine, spruce, and douglas-fir slash in (1) supplying breeding material for insects which emerge and kill mature standing timber or seedlings, saplings, and poles, and (2) attracting insects from the surrounding forest and concentrating them where they kill living trees. For the southern pine region the authors conclude that slash serving as breeding material for *Ips* spp. is not a menace, but that because of the attraction which it exerts, local logging or clearing operations in the summer should be avoided.

ECOLOGY, CULTURAL CONTROL

400 U. S. Dep. Agric., Bureau of Entomology and Plant Quarantine.

1951. **The more important forest insects in 1950— a summary.** U. S. Dep. Agric. Bur. Entomol. Plant Quar. Insect Pest Survey Special Supplement (1951, No. 4). 14 p.

Reports that the black turpentine beetle was becoming very aggressive throughout the South, affecting naval stores and drought-stressed trees in Florida and trees damaged during logging in Texas. About 1 million board feet of beetle-killed timber were salvaged from 30,000 acres in Louisiana.

OUTBREAK, TREE MORTALITY

401 U. S. Dep. Agric., Bureau of Entomology and Plant Quarantine.

1952. **The more important forest insects in 1951 — a summary.** U. S. Dep. Agric. Bur. Entomol. Plant Quar. Cooperative Economic Insect Rep. 1:88-106.

Reports that the black turpentine beetle was a serious problem in Texas, Louisiana, Mississippi, Florida, and North Carolina in 1951 and cites examples of timber losses and chemical control practices. The 3 *Ips* species were as serious as in the drought year of 1948, killing over 125 million board feet of timber. "In Texas death of trees, probably by *Ips avulsus*, began with killing from the top downward and in October killing by *Ips* bark beetles was more common than caused by the southern pine beetle."

OUTBREAK, TREE MORTALITY

402 U. S. Forest Service, Southeastern Forest Experiment Station.

1956. **Black turpentine beetle.** Pages 74-75 in Demmon, E.L. [director]. 1955 Annual Report, Southeastern Forest Experiment Station. Asheville, NC.

Gives board-feet volume losses for pine killed by *Dendroctonus terebrans* in a 37-county area of south Georgia in 1954 and 1955. Briefly summarizes results of two large chemical control studies in north Florida and studies of the root-attack habits of this beetle.

ATTACK, OUTBREAK, SURVEYS, CHEMICAL CONTROL, APPLIED CONTROL, TIMBER LOSSES

403 U. S. Forest Service, Southeastern Forest Experiment Station. 1957. **Forest insects.** Pages 39-42 in Pechanec, J.F. [director]. 1956 Annual Report, Southeastern Forest Experiment Station. Asheville, NC.
Briefly describes black turpentine beetle conditions in the southeast and measures taken to control the beetle at several locations. No major *Ips* spp. outbreak was detected in the southeast in 1956.
CHEMICAL CONTROL, APPLIED CONTROL

404 U. S. Forest Service, Southern Forest Experiment Station. 1955. **Black turpentine beetle remains a problem in many areas.** Page 68 in Briegleb, P.A. [director]. 1954 Annual Report, Southern Forest Experiment Station. New Orleans, LA.
Briefly mentions research undertaken to develop rules for marking infested trees for salvage cutting. Also states that the principal disturbances found to be favoring black turpentine beetle outbreaks were southern pine beetle outbreaks, hail, fire, and logging (especially in dry years).
ATTACK, STAND CONDITIONS, SITE FACTORS, HAIL, FIRE

405 U. S. Forest Service, Southern Forest Experiment Station. 1956. **Black turpentine beetle often follows selective logging.** Page 50 in Briegleb, P.A. [director]. 1955 Annual Report, Southern Forest Experiment Station. New Orleans, LA.
Warns of black turpentine beetle build-up following selective logging, particularly along creek bottoms and other normally wet sites. States that salvage logging of infested trees seldom controls the beetle and that spraying BHC on stumps and the bases of infested green trees may be required.
CHEMICAL CONTROL, STAND CONDITIONS

406 U. S. Forest Service, Southern Forest Experiment Station. 1957a. **Black turpentine beetle continues destructive.** Pages 67-68 in Briegleb, P.A. [director]. 1956 Annual Report, Southern Forest Experiment Station. New Orleans, LA.
Briefly describes some physical factors predisposing forest stands to black turpentine beetle attack and mentions the use of BHC-fuel oil spray combined with salvage cutting to control the beetle.
DAMAGE, CHEMICAL CONTROL, STAND CONDITIONS

407 U. S. Forest Service, Southern Forest Experiment Station. 1957b. **The black turpentine beetle.** Page 4 in Southern Forest Pest Reporter No. 16. New Orleans, LA: U. S. For. Serv. South. For. Exp. Stn. 7 p.
Describes a black turpentine beetle infestation in Louisiana that developed in natural loblolly pine stands in areas flooded by the Red River and Saline Lake from early May to mid-July 1957.
PHYSICAL FACTORS, CHEMICAL CONTROL, APPLIED CONTROL, STAND CONDITIONS, SITE FACTORS, FLOODING

408 Vaartaja, O.
1967. **The common fungal associates of the bark beetle, *Ips grandicollis*, in *Pinus radiata* in south Australia.** Aust. For. Res. 2(4):40-43.
*Ceratocystis ips* and *Macrophoma sabinea* [ = *Diplodia pinea*] were the fungi most frequently isolated from *Ips grandicollis* galleries, larvae, and adults.
FUNGI, YEASTS

409 Vité, J.P.; Gara, R.I.; Von Scheller, H.D.
1964. **Field observations on the response to attractants of bark beetles infesting southern pines.** Contrib. Boyce Thompson Inst. 22(8):461-470. 3 figs, 4 refs.
The first study to demonstrate that the three *Ips* species respond in large numbers to log sections recently infested by their respective species. The effects of season, temperature, wind, and rainshowers on the diurnal response patterns are also described. Additional data included are the diurnal patterns of emergence and dispersal for the 3 *Ips* species and the responses of other bark beetles and associated insects to infested material. Briefly describes seasonal changes in the diurnal flight activity of the black turpentine beetle.
AGGREGATION PHEROMONES, ATTRACTANTS, KAIROMONES, ALPHA-PINENE, BETA-PINENE, LIMONENE

410 Vité, J.P.; Pitman, G.B.
1967. **Concepts in research on bark beetle attraction and manipulation.** Proc. XIV Intern. Union Forest Res. Organ., Munich, 1967. Section 24, pp. 683-701.
Briefly reviews the literature on the diversity of bark beetle responses to plant- and insect-produced attractants and discusses the problems and potential for manipulating field populations.
PHEROMONES, AGGREGATION PHEROMONES, SEMIOCHEMICALS, ATTRACTANTS

411 Vité, J.P.; Renwick, J.A.A.
1971. **Population aggregating pheromone in the bark beetle, *Ips grandicollis*.** J. Insect Physiol. 17:1699-1704.
Comparative gas chromatography of the hindgut volatiles from feeding male *Ips paraconfusus*, *I. grandicollis*, and *I. calligraphus* lead to the identification of 2-methyl-6-methylene-7-octen-4-ol [ = ipsenol] as an aggregation pheromone for *I. grandicollis*.
AGGREGATION PHEROMONES. 2-METHYL-6-METHYLENE-7-OCTEN-4-OL, IPSENOL, TRANS-VERBENOL, CIS-VERBENOL, ALPHA-PINENE, ATTRACTANTS

412 Vité, J.P.; Bakke, A.; Renwick, J.A.A.
1972. **Pheromones in *Ips* (Coleoptera: Scolytidae): Occurrence and production.** Can. Entomol. 104:1967-1975.
Comparative gas chromatography was used to determine the prevalence of cis- and trans-verbenol, ipsdienol, and ipsenol in the hindguts of 12 *Ips* species feeding in fresh host material. Studies with *I. calligraphus* detected known pheromones in the hindgut, but not the midgut of individual males. Verbenol was produced within a few hours when beetles were exposed to oleoresin vapors. The authors discuss the role of "contact" and "frass" pheromones in the attack and colonization of trees.
PHEROMONES, PHEROMONE PRODUCTION, CIS-VERBENOL, TRANS-VERBENOL, IPSDIENOL, IPSENOL

413 Vité, J.P.; Hedden, R.L.; Mori, K.
1976. ***Ips grandicollis*: Field response to the optically pure pheromone.** Naturwissenschaften 63:43-44.
Field tests with optically pure enantiomers of ipsenol suggest that (S)-(—)-ipsenol is the actual aggregation pheromone for *Ips grandicollis*. The inactive isomer and ipsdienol did not inhibit response to the active isomer.
AGGREGATION PHEROMONES, IPSENOL, IPSDIENOL

414 Vité, J.P.; Renwick, J.A.A.
1976. **Applicability of bark-beetle pheromones: Configuration and consequences.** Z. Angew. Entomol. 82:112-116. [In German with English abstract.].
Discusses the need to consider the effects of the optical isomers of pheromones when using synthetic pheromones for surveys and control of bark beetles.
PHEROMONES, SURVEYS, APPLIED CONTROL, BREVICOMIN, FRONTALIN, IPSENOL

415 Vité, J.P.; Francke, W.
1976. **The aggregation pheromones of bark beetles: Progress and problems.** Naturwissenschaften 63:550-555. 68 refs.
An easily read review of the progress made at identifying and under-

standing the pheromone systems of bark beetles. The pheromone systems for 16 species are classified as belonging to a single component [ = *Ips grandicollis*], opposite-sex component, dual component [ = *I. calligraphus*], multiple component, or pheromone-kairomone system [ = *I. avulsus*]. The authors also discuss the methodology and limitations of applying pheromones to control or manage bark beetle populations.
AGGREGATION PHEROMONES, KAIROMONES, IPSENOL, IPSDIENOL, CIS-VERBENOL, TRANS-VERBENOL, FRONTALIN, BREVICOMIN, SEUDENOL, ALPHA-MULTISTRIATIN

416 Vité, J.P.; Klimetzek, D.; Loskant, G.; Hedden, R.L.; Mori, K.
1976. **Chirality of insect pheromones: Response interruption by inactive antipodes.** Naturwissenschaften 63:582-583.
*Ips calligraphus* response to ipsdienol and (s)-cis-verbenol was drastically suppressed when (r)-cis-verbenol was included in a concentration at least 10-fold higher than the (s)-enantiomer. The data suggest that " inactive" enantiomers must be present in higher concentrations than the "active" enantiomers in order to inhibit the effect of the pheromone.
PHEROMONE RECEPTION, AGGREGATION PHEROMONES, IPSDIENOL, CIS-VERBENOL, DISPARLURE

417 Vité, J.P.; Ohloff, G.; Billings, R.F.
1978. **Pheromonal chirality and integrity of aggregation response in southern species of the bark beetle *Ips* sp.** Nature 272:817-818.
Presents new data on the responses of *Ips calligraphus* and *I. avulsus* to enantiomers of ipsdienol and summarizes the aggregation pheromone systems for these two species plus *I. grandicollis* and *I. paraconfusus*.
PHEROMONES, VERBENOL, CIS-VERBENOL, IPSENOL, IPSDIENOL

418 Walker, L.C.
1956.
Erroneous authorship cited in some publications. See Harrison 1956 for correct information.

419 Walrod, A.L.
1970. ***Ips* bark beetle activity in hail-damaged timber.** Fayetteville, Arkansas: Univ. of Ark. M. S. Thesis. vi + 141 p. 6 tabs, 28 figs, 24 refs, 8 apps.
Bark beetles were not a significant factor causing tree mortality in loblolly and shortleaf pine stands severely damaged by hail on 27 April 1968. *Ips grandicollis* was the most numerous of the bark beetles, actively attacking fresh logging slash and standing dead trees. *Ips calligraphus* was observed in the lower 6 m of standing dead trees between 5 July and 7 September. Neither *Ips avulsus* nor *Dendroctonus terebrans* was present in large numbers.
PHYSICAL FACTORS, HAIL, TREE SUSCEPTIBILITY, STRESS, OLEORESIN EXUDATION RATE

420 Watterson, G.P.; Payne, T.L.; Richerson, J.V.
1982. **The effects of verbenone and brevicomin on the within-tree populations of *Dendroctonus frontalis*.** J. Ga. Entomol. Soc. 17:118-126. 2 tabs, 1 fig, 16 refs.
Placing inhibitors on trees at the margin of a southern pine beetle infestation reduced subsequent SPB egg and emergence densities, but resulted in much higher densities of *Ips avulsus*. The authors suggest that the reductions in SPB brood populations were primarily due to interspecific competition.
PHEROMONES, INHIBITORS, VERBENONE, ENDO-BREVICOMIN, COMPETITION

421 Weidensaul, T.C.
1963. **Investigations of the black turpentine beetle (*Dendroctonus terebrans* Hopkins [sic]) in relation to possible transmission of *Fomes annosus* (Fr.) Cke.** Durham, NC: Duke Univ. School of Forestry. iii + 50 p. 15 tabs, 23 refs. Thesis.
*Fomes annosus* was isolated from 25 percent of the *Dendroctonus terebrans* galleries sampled and from 17 percent of the parent beetles taken from the galleries. *Ceratocystis ips*, *Trichoderma* spp., and *Peniophora gigantea* were among the other fungi isolated.
FUNGI

422 Werner, R.A.
1971. **Studies on the olfactory response of *Ips grandicollis* (Eichhoff) (Coleoptera: Scolytidae) to host- and insect-produced attractants.** Raleigh, NC: North Carolina State Univ. Available from: University Microfilms, Ann Arbor, MI: Publication number 71-24,352. 159 p. Dissertation.
Laboratory and field experiments showed that aggregation is dependent, in part, on a combination of host- and insect-produced chemical compounds. The degree of host attractiveness depends on the qualitative and quantitative composition of volatile terpenes which are regulated by the physiological condition of the host.
AGGREGATION PHEROMONES, ATTRACTANTS, TREE PHYSIOLOGY

423 Werner, R.A.
1972. **Aggregation behaviour of the beetle *Ips grandicollis* in response to host-produced attractants.** J. Insect Physiol. 18:423-437. 7 tabs, 1 fig, 13 refs.
Laboratory bioassays indicated an adult preference for *Pinus taeda* over *P. strobus*, *Picea abies*, *Abies fraseri*, *Juniperus virginiana*, and *Tsuga canadensis*. Newly emerged beetles responded to odors from pine phloem, but not to bark and xylem tissues. The composition and attractiveness of phloem terpenes at four heights in normal and physiologically weakened loblolly pines is reported.
ATTRACTANTS, BEHAVIOR, HOST FINDING, BROOD MATERIAL, HOST TREES, OLEORESIN PRODUCTION, GERANIOL, MYRCENE, METHYL CHAVICOL, CAMPHENE, LIMONENE, ALPHA-PINENE, BETA-PINENE, TERPENES

424 Werner, R.A.
1972. **Aggregation behaviour of the beetle *Ips grandicollis* in response to insect-produced attractants.** J. Insect Physiol. 18:1001-1013. 5 tabs, 2 figs, 32 refs.
Laboratory bioassays demonstrated that the frass produced by males was attractive to both sexes, but the frass produced by virgin females was not attractive. Factors influencing response rates were beetle sex, age, reproductive condition, and nutritional state, plus the amount of frass and the air-flow rate.
FRASS PRODUCTION, BIOASSAYS, AGGREGATION PHEROMONES, BEHAVIOR

425 Werner, R.A.
1972. **Response of the beetle, *Ips grandicollis*, to combinations of host and insect produced attractants.** J. Insect Physiol. 18:1403-1412. 6 tabs, 19 refs.
Laboratory and field bioassays indicated that a combination of host terpenes and frass from male *Ips grandicollis* is probably one of the primary mechanisms involved in the mass attack and aggregation of *Ips grandicollis* populations.
AGGREGATION PHEROMONES, SEMIOCHEMICALS, ATTRACTANTS, TERPENES, FRONTALIN, TRANS-VERBENOL, ALPHA-PINENE, BETA-PINENE, CAMPHENE, LIMONENE, METHYL CHAVICOL, GERANIOL, MYRCENE

426 White, R.A., Jr.; Franklin, R.T.; Agosin, Moises
1979. **Conversion of alpha-pinene to alpha-pinene oxide by rat liver and the bark beetle *Dendroctonus terebrans* microsomal fractions.** Pestic. Biochem. Physiol. 10:233-242. 1 tab, 6 figs, 22 refs.
The metabolism of alpha-pinene was examined using microsomal fractions from larval and adult *Dendroctonus terebrans* and rat liver. Under hydroxylating conditions, both insect and rat liver microsomes converted alpha-pinene into alpha-pinene oxide and several other unidentifiable products. The role of cytochrome P-450 linked reactions in the production of insect pheromones via the alpha-pinene epoxide intermediate is discussed.
PHYSIOLOGY, METABOLISM, PHEROMONES, ALPHA-PINENE, MONOTERPENES

427 Wickham, H.F.
1896a. **A list of the Coleoptera from the southern shore of Lake Superior.** Proc. Davenport Acad. Nat. Sci. 6:169.
Not seen. According to Hopkins (1909a, p. 157), the list should read *Dendroctonus valens*, not *D. terebrans*.
DISTRIBUTION

428 Wickham, H.F.
1896b. **A list of some Coleoptera from the northern portion of New Mexico and Arizona.** Bull. Lab. Nat. Hist. State Univ. Iowa 3(4):170.
Not seen. According to Hopkins (1909a, p. 157), the list should read *Dendroctonus valens*, not *D. terebrans*.
DISTRIBUTION

429 Wickham, H.F.
1898. **The beetles of southern Arizona.** Bull. Lab. Nat. Hist. State Univ. Iowa 4(3):312.
Not seen. According to Hopkins (1909a, p. 157), the list should read *Dendroctonus valens*, not *D. terebrans*.
DISTRIBUTION

430 Wickham, H.F.
1902. **A catalogue of the Coleoptera of Colorado.** Bull. Lab. Nat. Hist. State Univ. Iowa 5(3):217-310.
Not seen. According to Hopkins (1909a, p. 157), the list on page 309 should read *Dendroctonus valens*, not *D. terebrans*.
DISTRIBUTION

431 Wilkinson, R.C.
1962. **Stridulating organs in three southeastern *Ips* bark beetles.** Fla. Entomol. 45:43-44. 1 fig, 1 ref.
Adult females of each species have a narrow, file-like organ (pars stridens) located on the posterior dorsal surface of the head capsule. The superposed complementary organ (plectrum) is an elliptical, striated plate on the anterior portion of the prothorax. Males lack these organs. The sex of living specimens can be determined at 10x magnification.
MORPHOLOGY, PARS STRIDENS, PLECTRUM, STRIDULATION, SEX DETERMINATION

432 Wilkinson, R.C.
1963. **Larval instars and head capsule morphology in three southeastern *Ips* bark beetles.** Fla. Entomol. 46:19-22. 1 tab, 3 figs, 1 ref.
A pair of tubercles on the frons of *Ips avulsus* larvae distinguishes this species from *I. grandicollis* and *I. calligraphus*. Head capsule measurements indicate that all three species have three larval instars.
MORPHOLOGY, FRONTAL TUBERCLES, LIFE HISTORY, GROWTH, INSTARS

433 Wilkinson, R.C.
1964. **Attraction and development of *Ips* bark beetle populations in artificially infested pine bolts exposed on firetowers and turntables in Florida.** Fla. Entomol. 47:57-64. 5 tabs, 1 fig, 4 refs.
(1) Non-infested phloem in longleaf and slash pine bolts is not strongly attractive to *Ips* species. (2) A method is presented for the establishment of either sex of *Ips* bark beetles in the inner bark of pine bolts. (3) The small southeastern species, *Ips avulsus*, is readily overcome with pitch in slash pine bolts during hot, wet weather. (4) *Ips grandicollis* and *Ips calligraphus* adults of both sexes will readily seek out and colonize male-infested host material suitable for brood production to elevations of at least 91 feet above ground level. (5) There is no evidence that a specific male-associated attraction extends to other *Ips* species. (6) Solitary *Ips grandicollis* females will produce brood in certain instances that is equal or greater in number than brood produced by females closely associated with males. (7) Caged longleaf pine logs artificially infested with *Ips calligraphus* males will attract adults of that species for at least three weeks in the field. (Author's summary)
REARING, BEHAVIOR, FLIGHT, HOST FINDING, ATTRACTANTS, DEVELOPMENT TIME

434 Wilkinson, R.C.; McClelland, W.T.; Murillo, R.M.; Ostmark, H.E.
1967. **Stridulation and behavior in two southeastern *Ips* bark beetles (Coleoptera: Scolytidae).** Fla. Entomol. 50:185-195. 2 tabs, 2 figs, 9 refs.
The possible effects of female stridulation on admittance to male nuptial chambers, mating, oviposition, and gallery system development were investigated in the laboratory with *Ips calligraphus* and *I. grandicollis*. The authors believe this is the first record of an acoustical courtship signal in a female arthropod.
MORPHOLOGY, PARS STRIDENS, PLECTRUM, BEHAVIOR, MATING, OVIPOSITION, STRIDULATION

435 Wilkinson, R.C.; Bhatkar, A.P.; Kloft, W.J.; Whitcomb, W.H.; Kloft, E.S.
1978. ***Formica integra* 2. Feeding, trophallaxis, and interspecific confrontation behavior.** Fla. Entomol. 61:179-187. 2 tabs, 1 fig, 26 refs.
*Ips calligraphus* and *I. grandicollis* adults were among the destructive forest insects consumed by the red wood ant, *Formica integra* Nylander, in laboratory screening tests.
BIOLOGY, PREDATORS

436 Wilkinson, R.C.; Britt, R.W.; Spence, E.A.; Seiber, S.M.
1978. **Hurricane-tornado damage, mortality, and insect infestations of slash pine.** South. J. Appl. For. 2:132-134. 3 figs, 9 refs.
*Ips* spp. and the black turpentine beetle infested severed and downed trees following a hurricane, but there was no spread of beetle populations into leaning or vertical trees. Contains recommendations on when to conduct salvage cuttings following hurricanes and tornadoes.
HOST TREES, STRESS, STAND CONDITIONS, HURRICANES

437 Wilkinson, R.C.
1979. **Tunneling in slash pine by *Ips calligraphus* (Germ.).** Fla. Entomol. 62:72-73. 1 fig, 5 refs.
Reports the occurrence of broad, vertical excavations made by *Ips calligraphus* females in apparently resistant slash pines characterized by relatively high oleoresin exudation pressures. This facultative tunneling behavior, similar to the excavations made by black turpentine beetle larvae, might explain the partial success of *I. calligraphus*

in attacking living trees.
BEHAVIOR, COLONIZATION, TUNNELING, HOST TREES, STRESS, OLEORESIN PRODUCTION

438 Wilkinson, R.C.; Foltz, J.L.
1980. **A selected bibliography (1959-1979) of three southeastern species of *Ips* engraver beetles.** Bull. Entomol. Soc. Am. 26:375-380.
Lists 182 references for *Ips avulsus, I. grandicollis* and *I. calligraphus*.
BIBLIOGRAPHY

439 Wilkinson, R.C.; Foltz, J.L.
1982. ***Ips* engraver beetles: Identification, biology, and control.** Ga. For. Comm. Res. Pap. 35. 10 p. 11 figs.
A general account and discussion of the biologies of the 3 southeastern *Ips* engravers and the factors playing key roles in their abundance. Contains guidelines for preventing and controlling *Ips* infestations under woodland conditions.
BIOLOGY, ECOLOGY, CULTURAL CONTROL

440 Williams, I.L.
1979. **Insecticide control in Florida: A progress report.** Pages 41-47 in Esser, M.H., ed. Sixth Annu. Lightwood Res. Conf. Proc.; 1979 January 17-18; Atlanta, Ga. Asheville, NC: U. S. For. Serv. Southeast. For. Exp. Stn. 151 p.
Lindane was the most effective and chlorpyrifos the next best of 4 insecticides tested for protecting paraquat-treated slash pines from insect attack.
CHEMICAL CONTROL, PERMETHRIN, CARBARYL, LINDANE, CHLORPYRIFOS, LIGHTWOOD INDUCTION, PARAQUAT

441 Williams, I. L.
1980. **Management of southern bark beetles.** Forest pest management symposium, Florida Section, Society of American Foresters, 3-4 June 1980. Gainesville, FL: Univ. Fl. School of Forest Resources and Conservation Resources Report 7:64-69. 12 refs.
Summarizes the biology, damage, and control of the black turpentine beetle and the *Ips* engraver beetles.
BIOLOGY, DAMAGE, APPLIED CONTROL

442 Williamson, D.L.
1971. **Olfactory discernment of prey by *Medetera bistriata* (Diptera: Dolichopodidae).** Ann. Entomol. Soc. Am. 64:586-589. 3 tabs, 2 figs, 12 refs.
*Medetera bistriata* responds to a bouquet of bark-beetle- and tree-produced stimuli and thus arrives at infested trees simultaneously with its prey species.
PREDATORS, KAIROMONES, FRONTALIN, ALPHA-PINENE, VERBENONE, VERBENOL

443 Wilson, G.R.
1968. **A study of factors affecting successful attack of loblolly pine (*Pinus taeda* L.) by *Ips* bark beetles (Coleoptera: Scolytidae).** Fayetteville, AR: Univ. Arkansas. ix + 49 p. 4 tabs, 6 figs, 38 refs. Thesis.
*Ips grandicollis* was successfully reared in the laboratory without its associated blue stain fungi, but attempts to have these beetles attack and infest living trees were unsuccessful. Artificial stressing of trees by several methods showed that trees which survived natural attacks had greater diameters, heights, and oleoresin exudation rates than trees which died. Tree survival was unrelated to dominance. *Ips avulsus* was the major species infesting the stressed trees, its attack density increasing with height; *I. grandicollis* densities were much lower and decreased slightly with increasing height.
REARING, FUNGI, ATTACK, STRESS, OLEORESIN EXUDATION RATE

444 Witanachchi, J.P.
1980. **Behaviour of *Ips grandicollis* (Eichhoff) (Coleoptera: Scolytidae).** Adelaide, Australia: Univ. of Adelaide. Dissertation.
Reports field and laboratory studies carried out in South Australia to obtain more information on the behavior of *Ips grandicollis* and the beetle's interactions with its host, *Pinus radiata* D. Don.
ECOLOGY, DISPERSAL, BEHAVIOR, MATING, HOST FINDING, HOST TREES, RESISTANCE, PHEROMONES, PHEROMONE PRODUCTION, IPSENOL

445 Witanachchi, J.P.
1980. **Evidence for pre-emergence mating among mature progeny of *Ips grandicollis* (Eichhoff).** J. Aust. Entomol. Soc. 19:93-100. 5 tabs, 3 figs, 17 refs.
Reports a series of experiments demonstrating that mature progeny may mate prior to emerging from the brood material, the proportion of mated females increasing in direct relation to the time between adult eclosion and emergence. All matings apparently occur beneath the bark, not in collecting jars or on the bark surface as some authors have suggested.
MATING

446 Witanachchi, J.P.; Morgan, F.D.
1981. **Behaviour of the bark beetle, *Ips grandicollis*, during host selection.** Physiol. Entomol. 6:219-223; 1981. 1 fig, 2 tabs, 15 refs.
Pretreatment sticky traps showed equal numbers of beetles landing on weak trees and vigorous trees in a *Pinus radiata* plantation in South Australia. When the trees were subsequently baited with ipsenol, trap catches on weak trees were twice the catch on vigorous trees. Attacking beetles bored into both kinds of trees, but gallery construction and oviposition occurred only in the weak trees. Gas chromatography showed that ipsenol was not produced by males that bored into and then retreated from vigorous trees. The authors infer that dispersing beetles land randomly on trees and that the decision to continue boring and to establish themselves, or to abandon boring and to retreat, is made during boring.
IPSENOL, HOST FINDING

447 Wood, D. L.
1961. **Stridulation in the genus *Ips* DeGeer.** Pan-Pac. Entomol. 37:187-188. 1 fig, 3 refs.
Reports the presence of a stridulating organ, the pars stridens, on the posterior dorsal area of the head for females of *Ips ponderosae* [= *I. calligraphus ponderosae*]. This organ and the sound produced provide a simple and rapid technique for sexing live beetles.
MORPHOLOGY, SEX DETERMINATION

448 Wood, D.L.; Stark, R.W.
1968. **Life history of *Ips calligraphus* (Coleoptera: Scolytidae) with notes on its biology in California.** Can. Entomol. 100:145-151. Addendum: Can. Entomol. 100:548. 3 figs, 20 refs.
Reports the seasonal development and habits of *Ips calligraphus* in the central Sierra Nevada mountains. Also reviews the geographic distribution and host trees for this species.
HOST TREES, DISTRIBUTION, BIOLOGY, LIFE HISTORY, REPRODUCTION, FECUNDITY, GROWTH, SEASONAL DEVELOPMENT, GALLERY PATTERN, HABITS

449 Wood, D.L.
1970. **Pheromones of bark beetles.** Pages 301-316 in Wood, D. L., Silvestein, R. M., and Nakajima, M., eds. Control of insect behavior by natural products. New York: Academic Press. 7 tabs, 46 refs.
Primarily a review of research done at the University of California

on the pheromones of *Ips confusus* and *Dendroctonus brevicomis*. Includes information (Table 4) that *Ips calligraphus* females respond in greater numbers to frass produced by *I. calligraphus* males than to frass from *I. plastographus* or *I. confusus*.
AGGREGATION PHEROMONES

450 Wood, D.L.
1982. **The role of pheromones, kairomones, and allomones in the host selection behavior of bark beetles.** Ann. Rev. Entomol. 27:411-446. 2 tabs, 232 refs.
The interspecific interactions among *Dendroctonus frontalis* and the three *Ips* species are cited in the discussion of the role of allomones in the colonization of trees by bark beetles.
PHEROMONES, ALLOMONES, KAIROMONES, BEHAVIOR, DISPERSAL, FLIGHT, HOST FINDING, ATTACK, COLONIZATION

451 Wood, S.L.
1957. **Distributional notes on and synonymies of some North American Scolytidae (Coleoptera).** Can. Entomol. 89:396-403.
*Ips cloudcrofti* Swaine (1924) is synonymized with *Ips cribricollis* (Eichhoff). [*Ips cribricollis* is now considered by some taxonomists as a synonym of *Ips grandicollis* (Eichhoff).]
TAXONOMY

452 Wood, S.L.
1963. **A revision of the bark beetle genus *Dendroctonus* Erichson (Coleoptera: Scolytidae).** Great Basin Nat. 23(1-2):71-82.
The similar species, *D. terebrans* (Olivier) and *D. valens* LeConte, are maintained as distinct species in this revision of the genus *Dendroctonus*. Contains extensive literature citations. The description of the biology of *D. terebrans* is based largely on earlier accounts by Hopkins (1909) and Blackman (1922).
TAXONOMY, BIOLOGY, BEHAVIOR, DAMAGE, HOST TREES, GEOGRAPHIC DISTRIBUTION

453 Wood, S.L.
1977. **New synonymy and new species of American bark beetles (Coleoptera: Scolytidae), part V.** Great Basin Nat. 37:383-394.
Proposes that *Ips cribricollis* (Eichhoff 1869) be regarded as a junior synonym of *I. grandicollis* (Eichhoff 1868). [Cf. Lanier 1970.]
TAXONOMY

454 Wood, S.L.
1982. **The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph.** Great Basin Nat. Mem. 6:1-1359.
Contains keys to and descriptions of 17 species of *Dendroctonus* (pp. 150-203) and 33 species and subspecies of *Ips* (pp. 667-705). Also provides information on diagnostic characters, adult morphology, geographic distribution, hosts, and biology for each species. Taxonomic synonyms listed for *Ips grandicollis* (Eichhoff 1868) are *Tomicus cacographus* LeConte (1868), *T. cribricollis* Eichhoff (1869), *Ips chagnoni* Swaine (1916), and *I. cloudcrofti* Swaine (1924). For *Ips calligraphus* (Germar 1824) the snynonyms are *Bostrichus exesus* Say (1826), *Tomicus praemorsus* Eichhoff (1868), *T. interstitialis* Eichhoff (1869), and *Ips ponderosae* Swaine (1925). No synonym is listed for *Ips avulsus* (Eichhoff 1868) or *Dendroctonus terebrans* (Olivier 1795).
TAXONOMY

455 Woodring, J.P.; Moser, J.C.
1970. **Six new species of Anoetid mites associated with North American Scolytidae.** Can. Entomol. 102:1237-1257. 37 figs, 18 refs.
Describes five new species of *Anoetus* and one new species of *Bonomoia* mites associated with North American bark beetles.
MITES

456 Woodring, J.P.; Moser, J.C.
1975. **Description of *Histiostoma conjuncta* (new comb.) (Acari: Anoetidae), an associate of Central American bark beetles.** Proc. Entomol. Soc. Wash. 77:83-86. 7 figs, 2 refs.
Taxonomic description of a mite collected from trees infested with *Ips avulsus*, *I. calligraphus*, and several other bark beetles.
MITES

457 Wray, C.
1951. **Biology of *Ips calligraphus* Germar.** Durham, NC: Duke Univ. Sch. of Forestry. v + 47 p. 4 tabs, 7 figs, 34 refs. Thesis.
A detailed description of *Ips calligraphus* gallery patterns, life history, and habits. *Dendroctonus terebrans*, *I. avulsus*, and *I. grandicollis* are listed among the 8 Scolytid species collected with *I. calligraphus*.
FUNGI, LIFE HISTORY, REPRODUCTION, EMERGENCE, SEX RATIO, EGGS, LARVAE, PUPAE, ADULTS, ASSOCIATES, GALLERY PATTERN, MATING, OVIPOSITION

458 Wyman, Lenthall
1932. **Experiments in naval stores practice.** U. S. Dep. Agric. Tech. Bull. 298. 60 p.
In his section on insect damage (pages 44-47), the author reports several instances of *Ips* spp. infesting turpentined trees following unusual flooding, droughts, fires, or excessive working of the trees. Although epidemics of these beetles are not uncommon, he feels that in nearly every case the insects may be considered of secondary importance, the primary cause of death being other injuries. [The black turpentine beetle is not even mentioned as a pest in naval stores stands.]
OUTBREAK, STRESS, NAVAL STORES

459 Yearian, W.C.; Wilkinson, R.C.
1963. **An artificial rearing medium for *Ips calligraphus* Germ.** Fla. Entomol. 46:319-320. 1 ref.
Only 10% of the eggs transferred from phloem to an artificial medium produced adults. Most mortality was associated with failure of the larvae to enter the medium after hatching or molting. [Better media and techniques are reported in Yearian and Wilkinson (1965).]
REARING

460 Yearian, W.C.; Wilkinson, R.C.
1965. **Two larval rearing media for *Ips* bark beetles.** Fla. Entomol. 48:25-27. 1 ref.
About 30% of the newly hatched larvae placed in a completely artificial medium developed to the adult stage. Survival averaged 50% in a phloem-based medium.
REARING, PHYSIOLOGY, DIET

461 Yearian, W.C.
1966. **Relations of the blue stain fungus, *Ceratocystis ips* (Rumbold) C. Moreau, to *Ips* bark beetles (Coleoptera: Scolytidae) occuring in Florida.** Gainesville, FL: Univ. Florida. ix + 81 p. 13 tabs, 12 figs, 65 refs. Dissertation. Available from University Microfilms, Ann Arbor, MI. Order no. 67-368.
See Yearian & Wilkinson 1967 and Yearian et al. 1972.
REARING, FUNGI, REPRODUCTION, FECUNDITY, DIET, GROWTH, DEVELOPMENT TIME

462 Yearian, W.C.; Wilkinson, R.C.
1967. **Development of three *Ips* bark beetles on a phloem-based rearing medium.** Fla. Entomol. 50:43-45. 1 tab, 5 refs.

Observations and rearing on a phloem-based medium at 30 deg. C showed mean incubation times for the egg stage of 2-3 days, larval stages of 8-9 days, and pupal stage of 3 days. *Ips calligraphus* and *I. grandicollis* pupae were heavier than wild pupae. *I. avulsus* pupae were lighter.
REARING, PHYSIOLOGY, DIET, GROWTH, DEVELOPMENT TIME

463 Yearian, W.C.; Gouger, R.J.; Wilkinson, R.C.
1972. **Effects of the bluestain fungus, *Ceratocystis ips*, on development of *Ips* bark beetles in pine bolts.** Ann. Entomol. Soc. Am. 65:481-487. 6 tabs, 18 refs.
The three southern *Ips* species were reared in slash pine logs in the presence and absence of *Ceratocystis ips* to determine its effects on beetle gallery length, brood size, beetle brood composition, pupal weight, and beetle fecundity. Beetles from wild sources were also compared with laboratory-reared beetles.
FUNGI, BIOLOGY, REPRODUCTION, FECUNDITY, PHYSIOLOGY, GROWTH

464 Younan, E.G.
1979. **Part I. Relative effectiveness of five trap designs for insects attacking severed shortleaf, Virginia, and loblolly pines; and Part II. Sequence of arrival of insects associated with bark beetles at severed shortleaf, Virginia, and loblolly pines.** Raleigh, N.C.; North Carolina State Univ. ix + 119 p. 14 tabs, 34 figs, 61 refs. Thesis.
*Ips avulsus* was by far the most abundant bark beetle trapped on recently severed shortleaf and loblolly pines even though the trees were adjacent to active *Dendroctonus frontalis* infestations. *Ips grandicollis, D. frontalis, D. terebrans*, and *I. calligraphus* were also collected at the shortleaf pines, and *I. grandicollis* and *D. frontalis* at the loblolly pines. *Ips grandicollis* was the predominant bark beetle (98.5% of catch) responding to severed Virginia pines, located 0.4 and 0.8 km from a *D. frontalis* infestation. [See Younan and Hain 1982 for information on the relative efficencies of the five trap designs.]
PARASITES, PREDATORS, ASSOCIATES, ATTACK, HOST FINDING

465 Younan, E.G.; Hain, F.P.
1982. **Evaluation of five trap designs for sampling insects associated with severed pines.** Can. Entomol. 114:789-796. 1 fig, 2 tabs. 10 refs.
A flight trap with baffles, modified from Hines and Heikkenen (1977), was superior to 4 designs employing sticky substances for capturing bark beetles and other beetles. [See Younan 1979 for additional data.]
TRAPS

466 Zimmermann, C.
1868. **Synopsis of the Scolytidae of America north of Mexico.** Trans. Am. Entomol. Soc. 2:141-149.
This classification of the Scolytidae, published by J. L. LeConte following Zimmermann's death, has *Ips avulsus, I. grandicollis*, and *I. calligraphus* in the genus *Bostrychus* as the species *B. avulsus, B. pini*, and *B. exesus*, respectively. A note by LeConte in the description of *B. pini* states, "This species is not that described by Say, but an allied one, which I have named *cacographus*." *Dendroctonus terebrans, D. frontalis*, and *D.* [=*Carphoborus*] *bifurcus* are the 3 North American species of *Dendroctonus*.
TAXONOMY

## AUTHOR INDEX

# KEYWORD INDEX

# INDEX TO BARK BEETLES

INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

TEACHING
RESEARCH
EXTENSION

IFAS

UNIVERSITY OF FLORIDA



ISSN 0735-0465